UNIVERSITY OF CENTRAL FLORIDA

IDS6938: Computational Optimization Models and Methods

School of Modeling, Simulation, and Training
College of Graduate Studies
Number of Credit Hours: 3

Course Syllabus

Instructor:	Ghaith Rabadi Bulent Soykan	Term:	Summer 2024 (Term C)
Office Location:	3100 Technology Parkway, Partnership II, Room#131	Class Meeting Days:	Monday
Office Hours:	Wednesdays 15:00 – 18:00 Preferably by appointment	Class Meeting Time:	5:30 – 8:20 pm
Phone:	(407) 882-1329	Class Location:	Partnership 3 Room 233 and online
Email:	Ghaith.Rabadi@ucf.edu Bulent.Soykan@ucf.edu	Course Modality:	In-person +online (Zoom)

GTA(s):	TBD	Email:	TBD

Course Description

This course provides students with a transformative learning experience by exploring the principles and applications of computational optimization. This course offers an in-depth exploration of computational optimization, focusing on models and methods applicable in various real-world scenarios. Starting with basic machine learning problems, the course progresses through sequential decision problems, optimization algorithms, linear programming, integer programming, advanced topics in optimization, metaheuristic algorithms, and simulation optimization methods. Students will gain a comprehensive understanding of optimization models, how to formulate them, and the algorithms used for solving complex decision problems. The course bridges the gap between theoretical optimization models and their practical application in complex scenarios across various industries.

In this course, we focus on developing effective computational methods for large-scale optimization problems, such as vehicle/crew routing, scheduling, network flows, inventory, and capacity allocation problems. Many of these problems pose significant challenges, both theoretically and practically. Despite the growing demand from industry, commercial optimization software often falls short in efficiently solving large instances of such problems.

Throughout the course, students will engage in various learning activities, such as readings, discussions, hands-on exercises, and assignments. Feedback and assessments will be provided to guide their progress and reinforce their learning. The course format will be hands-on, promoting active learning and collaboration. The course embraces a flipped learning approach, combining in-class activities with pre-class readings and online resources. By the end of the course, students will have a comprehensive understanding of computational optimization models and methods. They will have developed critical thinking skills, enhanced problem-solving abilities, and acquired practical insights that can be applied in diverse domains. This course empowers students to become self-directed learners and capable of making informed decisions.

Students will engage in both theoretical and computational problem-solving activities. Evaluation will be based on assignments (30%), a midterm exam (30%) and a final exam (40%). The primary objective of the computational assignments is to cultivate proficiency in designing and implementing optimization methods.

Course Purpose

The overarching purpose of this course is to equip students with a thorough understanding of the principles, models, and methods that underpin computational optimization and to provide practical experience in applying these concepts to solve real-world problems. Optimization problems pervade various domains, including engineering, economics, logistics, healthcare, and beyond, making the ability to analyze and solve these problems a highly valuable skill.

By integrating theoretical foundations with hands-on modeling, programming, and problem-solving experiences, the course aims to prepare students not just as theoreticians but as practitioners capable of contributing to their fields of interest. Ultimately, students completing this course will emerge with a strong foundational knowledge and applied skills, positioning them as valuable contributors to industries and disciplines where optimization plays a crucial role.

Students will gain:

- **Critical Problem-Solving Skills**: The ability to dissect complex, multidimensional problems and devise effective solutions.

- **Theoretical Understanding and Practical Application**: Balancing theoretical understanding with practical application to ensure students can contribute immediately and effectively in their chosen fields.

- **Interdisciplinary Knowledge**: Optimization is inherently interdisciplinary, allowing students to apply knowledge from this course in various domains, fostering innovation and efficiency.

- **Career Readiness**: Proficiency in computational optimization opens doors to careers in modeling & simulation, data science, optimization, logistics, and more.

This course matters because it provides the foundational knowledge and skills necessary to tackle some of the most pressing and complex problems faced by various industries today. By understanding and applying the principles of computational optimization, students can drive improvements, innovation, and efficiency within their organizations and society at large.

Enrollment Requirements

Prerequisites:

- An introductory mathematics course that covers basic linear algebra, calculus, and probability.
- An introductory programming course in Python (there will be refresher module to get the students up to speed.)

Please note that fulfilling the prerequisites is essential to ensure students have the necessary knowledge and skills to engage in the course material effectively. Students are encouraged to consult with their academic advisors if they have any questions or concerns about meeting the enrollment requirements for this course.

Course Materials and Resources

Required Materials/Resources

- Warren Powell, Sequential Decision Analytics and Modeling, NOW Press, 2022 (available for free download from https://tinyurl.com/sdamodeling).

Optional Materials/Resources

- Model Building in Mathematical Programming, 5th Edition, H. Paul Williams, ISBN: 978-1-118-44333-0, March 2013
- Warren Powell, Reinforcement Learning and Stochastic Optimization, Wiley, 2022 (see https://tinyurl.com/RLandSO/ for an overview).
- Applied Mathematical Programming by Bradley, Hax, and Magnanti. This book has very broad coverage of optimization models as well as algorithms. This book is available online at http://web.mit.edu/15.053/www/index.html .
- Operations Research Applications and Algorithms 4th Edition, Wayne L. Winston, Cengage Learning, 978-0534380588, 2003.
- Carter, M.W., Price, C.C., and Rabadi, G. (2018) “Operations Research: a Practical Introduction” 2nd edition, CRC Press, Taylor & Francis Group.
- Heuristics, metaheuristics and approximate methods in planning and scheduling. Vol. 236. Rabadi, Ghaith, ed., Springer, 2016.
- A list of recommended readings, including scholarly articles, research papers, or book chapters, will be provided throughout the course. These materials will enhance your understanding of the subject matter and support your learning.

Online Materials:

The course will utilize Webcourses@UCF as the primary online platform for accessing course materials, submitting assignments, participating in discussions, and accessing supplementary resources. Please ensure you have regular access to the internet and familiarity with the platform. If you encounter any challenges accessing online materials or have difficulty obtaining the required resources, please reach out to the instructor for assistance. The course materials have been carefully selected to support your progress in achieving the student learning outcomes and to provide a comprehensive learning experience.

Student Learning Outcomes

The course is designed to provide a comprehensive foundation in computational optimization, blending theory with practical application, and fostering skill development in problem-solving, critical thinking, and software use for optimization challenges. Given this context, the Student Learning Outcomes (SLOs) encapsulate not only the acquisition of knowledge but also the development of skills and abilities that will prepare students for real-world challenges. SLOs of the course include the following:

SLO 1: Analyze and apply the basic concepts and principles of computational optimization.
Measurement: This outcome will be measured through completion and evaluation of assignments and exams. Assignments will present students with problem-solving scenarios requiring the application of optimization concepts. Exams will test students' understanding and ability to analyze these concepts in both theoretical and applied contexts.

SLO 2: Design and implement optimization models and algorithms using programming languages and software tools.
Measurement: Students' proficiency will be measured by evaluating the programming assignments they complete. The assignments will require them to code optimization algorithms to solve given problems, use specific software packages, and demonstrate a working solution. The assignments will be assessed on criteria such as correctness, efficiency, and creativity in solution design.

SLO 3: Critically evaluate optimization models and methods, considering their strengths, limitations, and potential applications.
Measurement: This outcome will be assessed through written assignments reports. Students will be tasked with analyzing various optimization models and methods, discussing their applicability, advantages, and constraints in different scenarios. Evaluation criteria will include depth of analysis, justification of opinions, and ability to propose improvements or alternatives.

SLO 4: Effectively communicate complex optimization concepts and results to a varied audience.
Measurement: Measurement will occur through the evaluation of the assignment reports, and participation in discussions. Ratings on clarity, coherence, and engagement will indicate achievement in this area.

SLO 5: Become self-directed learners who can independently explore advanced topics in computational optimization.
Measurement: This will be measured through the assignments. Assessment will consider the depth and breadth of the topic explored, evidence of independent learning, and the ability to apply new knowledge to solve an advanced problem.

Course Activities

Assignments: Assignments are designed to reinforce the concepts and skills introduced in lectures and readings, providing students with practical experience in computational optimization. These will typically involve problem-solving exercises, programming and modeling tasks, and case study analyses. Assignments are intended to be challenging but achievable, prompting students to apply theoretical knowledge to practical scenarios.

Exams: The course will include a midterm exam and a comprehensive final exam. These exams aim to assess students' understanding of key concepts, theories, and their ability to apply these in various contexts.

- **Midterm Exam**: Covers material from the first half of the course, including basic optimization concepts, linear programming, and the introduction to integer programming. The format will include multiple-choice, short-answer, and problem-solving questions.

- **Final Exam**: As per UCF policy, this comprehensive exam will assess students' mastery of the course content, including all topics covered throughout the semester. The final exam will require deeper analysis and application of optimization methods. The final exam will be presented as a take-home assessment.

Extra Credit: This course does not offer extra credit. The assignments, and exams are designed to comprehensively cover and assess the knowledge and skills integral to computational optimization. Students are encouraged to focus on these components to maximize their learning and performance.

Resources or Actions:

- **Regular Internet Access**: Students are required to have regular access to the internet. Much of the course content, including readings, assignments, and resources, will be provided or submitted online. Regular access ensures that students can stay up-to-date with course materials and announcements.

- **Weekly Engagement**: Students should plan to log into the course at least twice each week. This will allow them to keep up with the lectures, assignments, and discussions, fostering a continuous learning process.

- **Assignments**: To achieve the learning outcomes of this course, students should anticipate dedicating at least five hours per week outside of class to completing readings, working on assignments, and engaging with supplementary materials.

- **Software Tools**: Assignments will require the use of specific software tools relevant to computational optimization. Students will be provided with information on how to access these tools and are expected to become proficient in their use as part of completing coursework.

Collaboration and Communication: Collaboration on assignments is encouraged, promoting a deeper understanding through discussion and shared problem-solving. However, students must ensure that any collaborative work adheres to the guidelines for academic integrity specified in the syllabus. Effective communication, both with peers and instructors, is crucial. Students are encouraged to participate actively in discussions and seek feedback on their work to enhance their learning experience.

These activities and requirements are designed to support students in achieving the course objectives, equipping them with the knowledge, skills, and abilities to excel in the field of computational optimization.

Activity Submissions

Assignment Submission

Webcourses@UCF Submission:

- Most assignments will be submitted through the course's Webcourses@UCF platform.
- Instructions for submitting assignments online will be provided for each specific assignment on the corresponding Webcourses page.
- Make sure to adhere to the given submission deadlines and any additional formatting requirements specified in the assignment instructions.

Assignment Formatting Guidelines:

- For written assignments, please follow the specified formatting guidelines, which may include font size, margins, line spacing, and citation style.
- Ensure that your assignments are legible, well-organized, and properly labeled.
- If electronic submission is required, please submit the files in compatible formats (e.g., PDF, Word) as instructed.

Note: It is essential to carefully review the assignment instructions for each specific task to understand the submission method, requirements, and any additional guidelines provided. Failure to follow the submission instructions may result in point deductions or assignment rejection.

Final Exam

This course will include a final examination in accordance with UCF policy. The final exam will assess your understanding of the course material and your ability to apply the concepts covered throughout the semester. Below are the details regarding the final exam:

Format:

- The final exam will be a take-home test.
- You will encounter a mix of assessment types, potentially including but not limited to multiple-choice questions, essays, problem-solving tasks, and practical scenarios requiring the application of optimization methods learned.
- The exam is structured to challenge your analytical abilities and depth of understanding, emphasizing real-world application and critical thinking.

Official Date and Time:

- The distribution of the take-home final exam will adhere to the university's academic calendar, with specific dates and times to be announced closer to the end of the semester.
- Please refer to the UCF Academic Calendar or consult your course schedule for detailed information regarding the distribution period for the take-home final exam.

Preparation for this final assessment is crucial, as it serves as an integral part of your learning evaluation. Detailed instructions, including submission guidelines and any necessary resources, will be provided upon the release of the exam. Planning your study schedule accordingly and ensuring timely completion and submission of the take-home exam are essential to meeting the course requirements.

Assessment and Grading Procedures

Grading Methods

In this course, your achievement of the student learning outcomes will be evaluated using a comprehensive grading system. The following elements will be considered in determining your final grade:

- Assignments
- Mid-term Exam
- Final Exam

Evaluation will be based on assignments (30%), a midterm exam (30%) and a final exam (40%). The primary objective of the computational assignments is to cultivate proficiency in designing and implementing optimization methods. Below table shows the weight distribution for each assignment.

Assignment	Percentage of Grade
Assignment 1	20%
Assignment 2	20%
Assignment 3	20%
Assignment 4	20%
Assignment 5	20%
Total	100%

Below table shows the range for each letter grade and uses a plus/minus system.

Letter Grade	Points
A	93 – 100 points
A-	90 – 92 points
B+	87 – 89 points
B	83 – 86 points
B-	80 – 82 points
C+	77 – 79 points
C	73 – 76 points
C-	70 – 72 points
D+	67 – 69 points
D	63 – 66 points
D-	60 – 62 points
F	59 and below

Consult the latest Graduate catalog for regulations and procedures regarding grading such as Incomplete grades, and grade changes.

Attendance/Participation

Please refer to the course expectations for the attendance policy.

Grade Dissemination

To ensure compliance with student privacy regulations, grades will not be released to third parties through public posting or sharing personal identifiers. Graded assignments will be returned to you individually through Webcourses@UCF. All grades will also be recorded in Webcourses@UCF for your reference and adherence to data security standards.

Course Schedule

Below weekly content is structured to ensure a logical flow from fundamental concepts to more advanced topics that allows students to apply what they've learned.

Week	Topic	Assignments
Week 1: Introduction to Computational Optimization	Overview of computational optimization; significance in solving real-world problems.	Read introductory materials and participate in a discussion forum about the applications of computational optimization in various industries.
Week 2: Basic Machine Learning for Optimization	Introduction to machine learning models and how they can be optimized.	Assignment 1: Complete a basic machine learning model optimization task using Python.
Week 3: Sequential Decision Problems	Understanding the framework for making decisions over time; introduction to decision trees.	
Week 4: Linear Programming	Linear programming formulations, graphical method, and modeling approaches	.
Week 5: Integer Programming	Introduction to integer programming; solving techniques and applications.	Assignment 2: Formulate and solve a linear programming and integer programming problems related to business operations
Week 6: Midterm Exam	Application of learned optimization techniques on a select problem.	
Week 7: Advanced Topics in Optimization (Dynamic Programming)	Introduction to dynamic programming and its applications in optimization.	Assignment 3: Solve a provided optimization problem using dynamic programming.
Week 8: Advanced Topics in Optimization (Multi-objective Optimization)	Fundamentals of multi-objective optimization and solving methods.	
Week 9: Metaheuristic Optimization Algorithms (Part 1: Evolutionary and Genetic Algorithms)	Introduction to evolutionary and genetic algorithms and their application in optimization problems.	Assignment 4: Implement a simple genetic algorithm for a given optimization problem.

Week 10: Metaheuristic Optimization Algorithms (Part 2: Simulated Annealing and Tabu Search)	Overview of simulated annealing and tabu search methods; comparison with genetic algorithms.	
Week 11: Simulation Optimization Methods	Foundation of various methods of simulation optimization	
Week 12: Simulation Optimization Applications	Application examples of implementing, running, and analyzing simulation optimization methods	Assignment 5: Optimizing simulation inputs for simulation output optimization

Policy Statements

Academic Integrity

Students should familiarize themselves with UCF's Rules of Conduct at <https://scai.sdes.ucf.edu/student-rules-of-conduct/>. According to Section 1, "Academic Misconduct," students are prohibited from engaging in

1. Unauthorized assistance: Using or attempting to use unauthorized materials, information or study aids in any academic exercise unless specifically authorized by the instructor of record. The unauthorized possession of examination or course-related material also constitutes cheating.
2. Communication to other students through written, visual, electronic, or oral means: The presentation of material which has not been studied or learned, but rather was obtained through someone else's efforts and used as part of an examination or course assignments.
3. Commercial Use of Academic Material: Selling of course material to another person, student, and/or uploading course material to a third-party vendor without authorization or without the express written permission of the university and the instructor. Course materials include but are not limited to class notes, Instructor's PowerPoints, course syllabi, tests, quizzes, labs, instruction sheets, homework, study guides, handouts, etc.
4. Falsifying or misrepresenting the student's own academic work.
5. Plagiarism: Using or appropriating another's work without any indication of the source, thereby attempting to convey the impression that such work is the student's own.
6. Multiple Submissions: Submitting the same academic work for credit more than once without the express written permission of the instructor.
7. Helping other students violate academic behavior standards.
8. Soliciting assistance with academic coursework and/or degree requirements.
9. **Use of AI only with acknowledgement**. Students are allowed to use Artificial Intelligence (AI) tools on assignments if the usage is properly documented and credited. Also, students must Not feed the assignment or part of it to an AI tool and simply use the

answer produced without any significant and meaningful contribution from the student that demonstrate what they learned in solving the assignment.

Responses to Academic Dishonesty, Plagiarism, or Cheating

Students should also familiarize themselves with the procedures for academic misconduct in UCF's student handbook, *The Golden Rule* <https://goldenrule.sdes.ucf.edu/>. UCF faculty members have a responsibility for students' education and the value of a UCF degree, and so seek to prevent unethical behavior and respond to academic misconduct when necessary. Penalties for violating rules, policies, and instructions within this course can range from a zero on the exercise to an "F" letter grade in the course. In addition, an Academic Misconduct report could be filed with the Office of Student Conduct, which could lead to disciplinary warning, disciplinary probation, or deferred suspension or separation from the University through suspension, dismissal, or expulsion with the addition of a "Z" designation on one's transcript.

Being found in violation of academic conduct standards could result in a student having to disclose such behavior on a graduate school application, being removed from a leadership position within a student organization, the recipient of scholarships, participation in University activities such as study abroad, internships, etc.

Let's avoid all of this by demonstrating values of honesty, trust, and integrity. No grade is worth compromising your integrity and moving your moral compass. Stay true to doing the right thing: take the zero, not a shortcut.

Unauthorized Use of Websites and Internet Resources

There are many websites claiming to offer study aids to students, but in using such websites, students could find themselves in violation of academic conduct guidelines. These websites include (but are not limited to) Quizlet, Course Hero, Chegg Study, and Clutch Prep. UCF does not endorse the use of these products in an unethical manner, which could lead to a violation of our University's Rules of Conduct. They encourage students to upload course materials, such as test questions, individual assignments, and examples of graded material. Such materials are the intellectual property of instructors, the university, or publishers and may not be distributed without prior authorization. Students who engage in such activity could be found in violation of academic conduct standards and could face course and/or University penalties. Please let me know if you are uncertain about the use of a website so I can determine its legitimacy.

Unauthorized Distribution of Class Notes

Third parties may attempt to connect with you to sell your notes and other course information from this class. Distributing course materials to a third party without instructor authorization is a violation of our University's Rules of Conduct. Please be aware that such class materials that may have already been given to such third parties may contain errors, which could affect your performance or grade. Recommendations for success in this course include coming to class on a routine basis, visiting me during my office hours, connecting with the Teaching Assistant (TA), and making use of the Student Academic Resource Center (SARC), the University Writing Center (UWC), the Math Lab, etc. If a third party should contact you regarding such an offer, I would appreciate your bringing this to my attention. We all play a part in creating a course climate of integrity.

In-Class Recording

Students may, without prior notice, record video or audio of a class lecture for a class in which the student is enrolled for their own personal educational use. A class lecture is defined as a formal or methodical oral presentation as part of a university course intended to present

information or teach enrolled students about a particular subject. Recording class activities other than class lectures, including but not limited to lab sessions, student presentations (whether individually or part of a group), class discussion (except when incidental to and incorporated within a class lecture), academic exercises involving student participation, test or examination administrations, field trips, private conversations between students in the class or between a student and the faculty member, and invited guest speakers is prohibited. Recordings may not be used as a substitute for class participation and class attendance, and may not be published or shared without the written consent of the faculty member. Failure to adhere to these requirements may constitute a violation of the University's Student Code of Conduct as described in the Golden Rule.

Course Accessibility Statement

The University of Central Florida is committed to providing access and inclusion for all persons with disabilities. Students with disabilities who need access to course content due to course design limitations should contact the professor as soon as possible. Students should also connect with Student Accessibility Services (SAS) <http://sas.sdes.ucf.edu/> (Ferrell Commons 185, sas@ucf.edu, phone 407-823-2371). For students connected with SAS, a Course Accessibility Letter may be created and sent to professors, which informs faculty of potential course access and accommodations that might be necessary and reasonable. Determining reasonable access and accommodations requires consideration of the course design, course learning objectives and the individual academic and course barriers experienced by the student. Further conversation with SAS, faculty and the student may be warranted to ensure an accessible course experience.

Campus Safety Statement

Emergencies on campus are rare, but if one should arise during class, everyone needs to work together. Students should be aware of their surroundings and familiar with some basic safety and security concepts.

- In case of an emergency, dial 911 for assistance.
- Every UCF classroom contains an emergency procedure guide posted on a wall near the door. Students should make a note of the guide's physical location and review the online version at <https://centralflorida-prod.modolabs.net/student/safety/index>.
- Students should know the evacuation routes from each of their classrooms and have a plan for finding safety in case of an emergency.
- If there is a medical emergency during class, students may need to access a first-aid kit or AED (Automated External Defibrillator). To learn where those are located, see <https://ehs.ucf.edu/automated-external-defibrillator-aed-locations>.
- To stay informed about emergency situations, students can sign up to receive UCF text alerts by going to <https://my.ucf.edu> and logging in. Click on "Student Self Service" located on the left side of the screen in the toolbar, scroll down to the blue "Personal Information" heading on the Student Center screen, click on "UCF Alert", fill out the information, including e-mail address, cell phone number, and cell phone provider, click "Apply" to save the changes, and then click "OK."
- Students with special needs related to emergency situations should speak with their instructors outside of class.
- To learn about how to manage an active-shooter situation on campus or elsewhere, consider viewing this video (<https://youtu.be/NIKYajEx4pk>).

Deployed Active Duty Military Students
Students who are deployed active duty military and/or National Guard personnel and require accommodation should contact their instructors as soon as possible after the semester begins and/or after they receive notification of deployment to make related arrangements.

Make-Up Assignments for Authorized University Events or Co-curricular Activities
Students who represent the university in an authorized event or activity (for example, student-athletes) and who are unable to meet a course deadline due to a conflict with that event must provide the instructor with documentation in advance to arrange a make-up. No penalty will be applied. For more information, see the UCF policy at <https://policies.ucf.edu/documents/4-401.pdf>

Religious Observances
Students must notify their instructor in advance if they intend to miss class for a religious observance. For more information, see the UCF policy at <http://regulations.ucf.edu/chapter5/documents/5.020ReligiousObservancesFINALJan19.pdf>.

Title IX Policy
Title IX prohibits sex discrimination, including sexual misconduct, sexual violence, sexual harassment, and retaliation. If you or someone you know has been harassed or assaulted, you can find resources available to support the victim, including confidential resources and information concerning reporting options at https://letsbeclear.ucf.edu and http://cares.sdes.ucf.edu/.