USC Viterbi
School of Engineering

Course ID and Title:
ITP499: Real-World Optimization: Techniques and Applications

Units: 4
Term—Day—Time: Spring 2025 – Tuesday, Thursday: 2:00 - 3:50 pm
Location: KAP 107

Instructor: Sinan Seymen, Ph.D.
Office: Rapp Engineering Building (RRB) Office 217
Office Hours: Listed on Brightspace and Piazza
Contact Info: seymen@usc.edu

Learning Assistants: Listed on Piazza
Office Hours: Listed on Piazza
Contact Info: Use Piazza

IT Help: Provided by Viterbi IT
Hours of Service: 8 am – 5 pm; M – F
Walk-in: DRB 205
Contact Info: (213) 740–0517
Email: engrhelp@usc.edu

Course Description
This course aims to teach the principles and practices of optimization and its applications across various fields. Students will develop problem-solving skills by applying optimization techniques to real-life challenges. The curriculum covers a range of optimization topics, including linear, integer, stochastic, and robust optimization, as well as greedy approaches for problem-solving. Additionally, students will gain hands-on experience with state-of-the-art optimization software and will learn to understand its syntax. Key problems explored in the course include the knapsack problem, portfolio management, scheduling, and minimum cost maximum flow paths in graphs. By the end of the course, students will be equipped to formulate and solve optimization models effectively.

Learning Objectives
Identify the building blocks of optimization models.
Discuss solutions to real-world scenarios in various fields such as engineering, economics, and logistics.
Construct mathematical optimization models.
Use optimization software tools to solve complex problems.
Differentiate between optimal and suboptimal solutions.
Evaluate results of algorithms and optimization models in a meaningful way.
Communicate results and insights effectively to both technical and non-technical audiences.

Prerequisite(s): None.
Recommended Preparation: Any programming experience from any point in your life.

Course Notes

This course will make use of **Brightspace** (https://Brightspace.usc.edu/) for all content. Lecture slides and any supplemental course content will be posted to Brightspace for use by all students. All assignments and projects will be posted to Brightspace and will be submitted through Brightspace. Please familiarize yourself with Brightspace before the course begins.

This course will also use **Piazza** (https://piazza.com/) for answering questions and posting information about office hours. This is the preferred way to communicate with instructors and learning assistants (LAs).

Technological Proficiency and Hardware/Software Required

Students will need a computer (laptop or desktop) and access to the internet. If you do not have access to a computer, please see below. The software needed for this course is available for **free** online. All homework and projects will need this software to be completed (available for Mac and Windows).

We will install **Gurobi** and receive a free student/educator license: https://www.gurobi.com/
Then, Gurobi API will be used in Python.

Download the latest version of **Python 3** at https://www.python.org/downloads/.

You will also need to download and install PyCharm, which is an integrated design environment (IDE) for writing code. Download the latest version of **PyCharm CE (Community Edition)** at https://www.jetbrains.com/pycharm/download/.

USC Technology Rental Program

If you need resources to successfully participate in your classes, such as a laptop or internet hotspot, you may be eligible for the university's equipment rental program. To apply, please submit an application. The Student Basic Needs team will contact all applicants and distribute equipment to eligible applicants prior to the start of the semester.

ITP Computers

ITP has a limited number of laptops that are available to borrow for ITP classes. Eligible students will be able to borrow a MacBook or Dell XPS for ITP coursework once their request is approved and their contract is signed via DocuSign. Though the initial loan period is 7 days, they will still be able to renew their device and extend the loan period as in previous semesters. They will need to pop into one of ITP's Zoom device check-in sessions before the end of each week. If all of them have been checked out, then the student will be placed on the waiting list. You will not be able to save your work on the ITP lab computers and the ITP laptops. Once they are restarted, all work will be deleted. Use an external USB drive, or a cloud-based service like Google Drive or Dropbox to save your work. ITP is not responsible for any lost work. Information about the ITP Loaner Laptop Program and the request form can be found at https://itp.usc.edu/current-students/itp-device-check-outs/.

Optional Readings and Supplementary Materials

All readings and supplementary materials in this class will be free to USC students. There is no required reading, but optional readings and supplementary material will be provided to strengthen student's understanding of the material.

Thie, Keough: Thie, P. R., & Keough, G. E. (2011). *An introduction to linear programming and game theory*. John Wiley & Sons.

Talbi: Talbi, E. G. (2009). *Metaheuristics: from design to implementation*. John Wiley & Sons.

Description of Assignments and How They Will Be Assessed

There will be approximately 9 assignments which will be due on Friday at 11:59 pm PT (Pacific Time). Each assignment covers the material from the current week (and past weeks since concepts build upon each other) and is due the following week. For example, Assignment 1 will be assigned week 2, and will be due on Friday of week 3. The assignments will be posted on Brightspace under the Assignments. Each assignment will include instructions, a rubric criteria and expectations, and a link for electronic submission. Assignments must be submitted using this link. If you need help, please ask for help by posting on Piazza and attending office hours.

Grading Breakdown

Category	% of Grade
Assignments (weighted proportionally)	40
Exam	30
Group Project	30
TOTAL	100

Group Project

There will be one project for this course. The project will be team-based, and students will create an optimization model of their choice applying the concepts learned throughout the semester. This project will have several milestones, during which students will discuss their progress with the instructor in meetings and submit their work at each stage. They will receive feedback after each milestone.

Students will have hands-on experience on:

- Modeling a problem
- Applying various optimization techniques to the problem
- Programming the solution in Gurobi and solve the problem
- Presenting their findings in a concise and impactful way
- Depending on available time, students will present their work in-class at the end of the semester.

Project grade distribution:

Final Project Rubric Description	% of Overall Grade
Problem Selection and Discussion	5
LP and IP modeling	10
Sensitivity Analysis	5
Greedy Approach and solution comparison	5
Final submission	5
TOTAL	30

Late projects will not be accepted. If you do not submit a final project or if you submit it past the deadline without instructor approval, you will receive a 0 for the final project.

Exam

There will be one in-class exam that will test the material covered. A make-up exam will not be offered, except for documented medical or family emergencies. If you cannot attend the exam due to an athletic game or other valid reason, then you must coordinate with the instructor before the exam is given. You may arrange to take the exam before you leave, with approved university personnel during the time you are gone, or within the week the exam is given. If you do not take an exam, then you will receive a 0 for the exam.

If you need accommodations, register with OSAS (Office of Student Accessibility Services). Once you receive your accommodation letter, share your letter with the instructor at least one week before the exam. You may give it to them in person, send an email, or post it on Piazza. This will allow time for arrangements to be made.

Grading Scale

Course final grades will be determined using the following scale:

Letter grade	Corresponding numerical point range
A	>= 93
A-	>= 90 and < 93
B+	>= 87 and < 90
B	>= 83 and < 87
B-	>= 80 and < 83
C+	>= 77 and < 80
C	>= 73 and < 77
C-	>= 70 and < 73
D+	>= 67 and < 70
D	>= 65 and < 67
F	< 65

For the Pass/No Pass grading option, you must earn at least 70% to pass.

Adding the Course after Week 1

Per university policy, students are allowed to add the course until the end of week 3. Any students wishing to add the course should plan on attending the course from the beginning of the semester. Upon adding the course after week 1, the student should email the instructor immediately to make a plan for the completion of work and learning missed materials. Any missed work is required to be completed and submitted according to the schedule provided by the instructor. If you register for the class after assignments are due, then you will have one week from when you registered for the class to submit the assignments. If you add the class during the third week of classes, then you must meet with the instructor to create a plan together on how to catch up to the rest of the class. By the end of week 3, two labs and two assignments are due.

Assignment Late Policy

It is the student's responsibility to submit assignments on or before the due date. Assignments may be submitted within five days with a late penalty. Assignments turned in one day (24 hours) late will have 10% of the total points deducted from the graded score for each late day. Assignments turned in over one day and up to two days (> 24 hours and <= 48 hours) late will have 20% of the total points deducted from the graded score and so on. After five days, submissions will not be accepted, and the score for the assignment will be a 0.

You may ask for an assignment's late policy to be waived for various reasons. This needs to be approved before the due date of the assignment, or within a couple of days. To ask for a waiver, please contact the instructor using Piazza or email. Do not contact LAs for this since they are not authorized to approve these requests.

Assignment Grading Timeline

Assignments will be graded within two weeks. Students have one week to contest a grade once it has been posted on Brightspace. After this one week, the grade will not be changed. To contest a grade, create a private post on Piazza and select the grades folder. In the post, include your name, your instructor, your section, the assignment name, and your reasons. This will allow the grader and instructor to view your submission and make a decision. Do not email the grader directly. All communication regarding grading issues needs to be seen and approved by the instructor.

Attendance

Attendance is not part of the grading breakdown, although attending classes will help you learn the material and succeed in this course. If you are not able to attend synchronously, then it is your responsibility to read and study the material posted on Brightspace.

Classroom Etiquette

The instructor expects you to pay attention during lectures and be an active learner. Chatting while the instructor is talking, texting on your mobile device, and participating on social media sites during class is disrespectful to the instructor and your classmates. If you are not able to attend lectures, then you should watch the recorded lectures and complete the in-class labs.

Communication

The preferred way to communicate with instructors and LAs is posting on Piazza http://piazza.com. All students enrolled in the class, instructors, and LAs will have access to the same class on Piazza. Information about accessing Piazza is available on Brightspace. If you have questions about assignments, labs, tests, and other aspects about this course, please post on Piazza. You are able to make public posts that all members can see and answer or private posts to individuals which are only accessible to instructors and LAs. To make a private post to all instructors and LAs, next to "Post to" select the "Individual Students(s) / Instructor(s)" option and enter "Instructors" in the text field.

Students should NOT directly email the LAs or graders: all correspondence with the LAs should be done on Piazza. If a direct email is required for any reason, the student must cc the instructor in the email.

OSAS Accommodations

If you have course accommodations authorized by OSAS (Office of Student Accessibility Services), please email the instructor or post privately on Piazza and attach your accommodation letter by the end of Week 3. In the body of the message, include your name and your class section. In addition, reach out the week before the test to discuss details for coordinating specific test accommodations.

Academic Integrity for this Class

Unless otherwise noted, this course will follow the expectations for academic integrity as stated in the USC Student Handbook. The general USC guidelines on Academic Integrity and Course Content Distribution are provided later in this syllabus.

For this class ...

- Assignments and exams: Students should NOT collaborate, work together, share code, or in any way exchange solutions for assignments or exams. You should show your own work.
- Group project: Unless specifically designated as a 'group project,' all assignments are expected to be completed individually.
- Computer programs: Plagiarism includes the submission of code written by, or otherwise obtained from someone else, without giving them the proper credit/citation.

Students suspected of engaging in academic misconduct will be reported to the Office of Academic Integrity. If found responsible for an academic violation, students may be assigned university outcomes, such as suspension or expulsion from the university, and grade penalties, such as an "F" grade on the assignment, exam, and/or in the course. Please ask the instructor if you are unsure about what constitutes unauthorized assistance on an exam or assignment, or what information requires citation and/or attribution.

Class Recordings and Course Content Distribution: You may not record this class without the express permission of the instructor and all other students in the class. Distribution of any notes, recordings, exams, or other materials from a university class or lectures — other than for individual or class group study — is prohibited without the express permission of the instructor; violations will be considered an intentional act to facilitate or enable academic dishonesty and reported to the university.

Use of Artificial Intelligence (AI) Tools like ChatGPT

I expect you to use AI (e.g., ChatGPT and image generation tools) in this class. Learning to use AI is an emerging skill, and I welcome the opportunity to meet with you to provide guidance with these tools during office hours or after class. Keep in mind the following:

AI tools are permitted to help you brainstorm topics or revise work you have already written.

If you provide minimum-effort prompts, you will get low-quality results. You will need to refine your prompts to get good outcomes. This will take work.

Proceed with caution when using AI tools and do not assume the information provided is accurate or trustworthy. If it gives you a number or fact, assume it is incorrect unless you either know the correct answer or can verify its accuracy with another source. You will be responsible for any errors or omissions provided by the tool. It works best for topics you understand.

AI is a tool, but one that you need to acknowledge using. Please include a paragraph at the end of any assignment that uses AI explaining how (and why) you used AI and indicate/specify the prompts you used to obtain the results and what prompts you used to get the results. Failure to do so is a violation of academic integrity policies.

Be thoughtful about when AI is useful. Consider its appropriateness for each assignment or circumstance. The use of AI tools requires attribution. You are expected to clearly attribute any material generated by the tool used.

Course Evaluations

Course evaluations take place university-wide at the end of each semester. These evaluations are a valuable review of students' experiences in the class. Students are invited to provide constructive feedback on the course content and their learning experience. This feedback helps instructors refine and improve course materials, ensuring that they better meet the needs and ideas shared by students.

Course Schedule: A Weekly Breakdown

	Topics	Supplementary Preparation	Deliverables
Week 1	• Course Overview • Discussion on Problem Solving and Decision Making • Introduction to Business Intelligence	-	Installing PyCharm and Gurobi
Week 2	• Review of Python Syntax and Data Types • Introduction to Pandas for Data Analysis • Numpy for Numerical Analysis • Matplotlib for Data Visualization	**ITP Playlist**	**Assignment 1:** Data reading and visualization in Python
Week 3	• Components of Constrained Optimization Modeling • Introduction to Linear Programming • 2D Representation of Optimization Models • Key Terminology in Optimization	**Thie, Keough** Chapters 1.1, 1.2	**Assignment 2:** Model a problem, solve it visually.
Week 4	• Creating Mathematical Models Using Python and Gurobi • Techniques for Implementing Optimization Models	Gurobi Python API	**Assignment 3:** Solve the models created in assignment 2 in Gurobi.
Week 5	• Introduction to Greedy Algorithms in Optimization • Solving Common Optimization Problems in Gurobi	Gurobi General Constraints **Thie, Keough** Chapters 2.2, 2.3	**Assignment 4:** Add new constraints to Assignment 3 model. **Project Milestone 1:** Group Forming
Week 6	• Introduction to Sensitivity Analysis • In-class Activity: **Knapsack Problems** • Discussion on Solution Approaches for Knapsack Problems	**Thie, Keough** Chapter 5.1	**Assignment 5:** Solve and compare Knapsack optimization solution to a greedy solution
Week 7	• Defining Optimization Models More Rigorously • Understanding Linear Programming Solution Methods • Introduction to Integer Programming (IP)	**Thie, Keough** Chapters 3.1, 6.1, 6.2, 6.4	**Assignment 6:** Application of sensitivity analysis. Solve Knapsack as an IP, compare with Assignment 5.
Week 8	• Continuation of Integer Programming (IP) • Discussion on Linearity and Convexity in Optimization • Introduction to Non-Linear and Non-Convex Programs • Discussion on Unconstrained Optimization	-	**Project Milestone 2:** Problem Selection
Week 9	• Review and Exam	-	-
Week 10	• Introduction to Heuristic Methods • Overview of Common Metaheuristic Algorithms • Investigating the **Traveling Salesman Problem (TSP)** • Visualizing Solutions in Python	**Talbi** Chapters 1.3.1-1.3.4	**Assignment 7:** Model Traveling Salesman Problem as IP and LP. Apply a simple heuristic approach.

Week 11	• Challenges in Routing Problems with MIP • Applying Metaheuristics to TSP: **Simulated Annealing and Genetic Algorithms**	**Talbi** Chapters 2.4, 3.2	**Assignment 8:** Solve TSP with metaheuristic. Compare solutions with Assignment 7 solutions.
Week 12	• Introduction to Robust Optimization Problems • Modeling and Solving Robust Problems • In-class Activity: **Supply Chain Optimization under Demand Uncertainty**	-	**Project Milestone 3:** Model and solve LP and IP versions. Apply sensitivity analysis and heuristic approaches. Compare solutions.
Week 13	• Introduction to Stochastic Optimization Problems • Modeling and Solving Stochastic Problems • In-class Activity: **Inventory Management with Random Demand**	**Thie, Keough** Chapter 8.1	**Assignment 9:** Robust and stochastic optimization modeling examples.
Week 14	• Introduction to Quadratic Programming (QP) • Modeling and Solving QP Problems • In-class Activity: **Portfolio Optimization**	-	-
Week 15	• Project Presentations	-	-
FINAL		-	**Project Milestone 4:** Final Project Submission

Statement on Academic Conduct and Support Systems

Academic Integrity

The University of Southern California is foremost a learning community committed to fostering successful scholars and researchers dedicated to the pursuit of knowledge and the transmission of ideas. Academic misconduct — which includes any act of dishonesty in the production or submission of academic work (either in draft or final form) — is in contrast to the university's mission to educate students through a broad array of academic, professional, and extracurricular programs.

This course will follow the expectations for academic integrity as stated in the USC Student Handbook. All students are expected to submit assignments that are their own original work and prepared specifically for this course and section in this academic term. You may not submit work written by others or "recycle" work prepared for other courses without obtaining written permission from the instructor(s). Students suspected of engaging in academic misconduct will be reported to the Office of Academic Integrity.

Other violations of academic misconduct include, but are not limited to, cheating, plagiarism, fabrication (e.g., falsifying data), knowingly assisting others in acts of academic dishonesty, and any act that gains or is intended to gain an unfair academic advantage.

Academic dishonesty has a far-reaching impact and is considered a serious offense against the university. Violations will result in a grade penalty, such as a failing grade on the assignment or in the course, and disciplinary action from the university itself, such as suspension or even expulsion.

For more information about academic integrity see the student handbook or the Office of Academic Integrity's website, and university policies on Research and Scholarship Misconduct.

Please ask your instructor if you are unsure what constitutes unauthorized assistance on an exam or assignment or what information requires citation and/or attribution.

Course Content Distribution and Synchronous Session Recordings Policies
USC has policies that prohibit recording and distribution of any synchronous and asynchronous course content outside of the learning environment.

Recording a university class without the express permission of the instructor and announcement to the class, or unless conducted pursuant to an Office of Student Accessibility Services (OSAS) accommodation. Recording can inhibit free discussion in the future, and thus infringe on the academic freedom of other students as well as the instructor. (Living our Unifying Values: The USC Student Handbook, page 13).

Distribution or use of notes, recordings, exams, or other intellectual property, based on university classes or lectures without the express permission of the instructor for purposes other than individual or group study. This includes but is not limited to providing materials for distribution by services publishing course materials. This restriction on unauthorized use also applies to all information, which had been distributed to students or in any way had been displayed for use in relation to the class, whether obtained in class, via email, on the internet, or via any other media. Distributing course material without the instructor's permission will be presumed to be an intentional act to facilitate or enable academic dishonestly and is strictly prohibited. (Living our Unifying Values: The USC Student Handbook, page 13).

Statement on University Academic and Support Systems

Students and Disability Accommodations:
USC welcomes students with disabilities into all of the University's educational programs. The Office of Student Accessibility Services (OSAS) is responsible for the determination of appropriate accommodations for students who encounter disability-related barriers. Once a student has completed the OSAS process (registration, initial appointment, and submitted documentation) and accommodations are determined to be reasonable and appropriate, a Letter of Accommodation (LOA) will be available to generate for each course. The LOA must be given to each course instructor by the student and followed up with a discussion. This should be done as early in the semester as possible as accommodations are not retroactive. More information can be found at osas.usc.edu. You may contact OSAS at (213) 740-0776 or via email at osasfrontdesk@usc.edu.

Student Financial Aid and Satisfactory Academic Progress:
To be eligible for certain kinds of financial aid, students are required to maintain Satisfactory Academic Progress (SAP) toward their degree objectives. Visit the Financial Aid Office webpage for undergraduate- and graduate-level SAP eligibility requirements and the appeals process.

Support Systems:
Counseling and Mental Health - (213) 740-9355 – 24/7 on call
Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

988 Suicide and Crisis Lifeline - 988 for both calls and text messages – 24/7 on call
The 988 Suicide and Crisis Lifeline (formerly known as the National Suicide Prevention Lifeline) provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week, across the United States. The Lifeline consists of a national network of over 200 local crisis centers, combining custom local care and resources with national standards and best practices. The new, shorter phone number makes it easier for people to remember and access mental health crisis services (though the previous 1 (800) 273-8255 number will continue to function indefinitely) and represents a continued commitment to those in crisis.

Relationship and Sexual Violence Prevention Services (RSVP) - (213) 740-9355(WELL) – 24/7 on call
Free and confidential therapy services, workshops, and training for situations related to gender- and power-based harm (including sexual assault, intimate partner violence, and stalking).

Office for Equity, Equal Opportunity, and Title IX (EEO-TIX) - (213) 740-5086
Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants.

Reporting Incidents of Bias or Harassment - (213) 740-2500
Avenue to report incidents of bias, hate crimes, and microaggressions to the Office for Equity, Equal Opportunity, and Title for appropriate investigation, supportive measures, and response.

The Office of Student Accessibility Services (OSAS) - (213) 740-0776
OSAS ensures equal access for students with disabilities through providing academic accommodations and auxiliary aids in accordance with federal laws and university policy.

USC Campus Support and Intervention - (213) 740-0411
Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

Diversity, Equity and Inclusion - (213) 740-2101
Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

USC Emergency - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call
Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

USC Department of Public Safety - UPC: (213) 740-6000, HSC: (323) 442-1200 – 24/7 on call
Non-emergency assistance or information.

Office of the Ombuds - (213) 821-9556 (UPC) / (323-442-0382 (HSC)
A safe and confidential place to share your USC-related issues with a University Ombuds who will work with you to explore options or paths to manage your concern.

Occupational Therapy Faculty Practice - (323) 442-2850 or otfp@med.usc.edu
Confidential Lifestyle Redesign services for USC students to support health-promoting habits and routines that enhance quality of life and academic performance.