ISE 330: Introduction to Operations Research: Deterministic Models

Units: 4

IMPORTANT:
The general expectation for a standard format course offered in a standard 15-week teradsfam is that the number of 50-minute contact hours per week should equal the number of semester units indicated and that one semester unit entails 1 hour of class time and 2 hours of outside work (3 hours total) per week. Standard fall and spring sessions (001) require a final summative experience during the University scheduled final exam day and time.

Please refer to the *Contact Hours Reference* to see guidelines for courses that do not follow a standard format and/or a standard term.

Location: Physical address and/or course-related URLs, etc.

Instructor: John Gunnar Carlsson
Office: OHE 310F
Office Hours: Tuesday, 11:30 – 12:30
Contact Info: jcarlsso@usc.edu and Slack. If you do not receive a response from me in 24 hours, please feel free to remind me; no offense will be taken!

Teaching Assistant: TBA
Office:
Office Hours:
Contact Info:.

USC Catalogue Description

Modeling, analysis solution, and applications of complex decision problems using linear, dynamic, and integer optimization.

Course Description

This course is a basic introduction to important models and solution methods in Industrial and Systems Engineering (ISE). ISE is concerned with the modeling, analysis, and solution of complex decision problems that arise in the management or design of a large-scale industrial system such as a supply chain, transportation network, or manufacturing assembly line. This course will focus specifically on the modeling and solution of linear programs, dynamic programs, and integer programs, as well as additional applications thereof in transportation, logistics, supply chain management, among others.

Learning Objectives

1. Obtain an overview of the kinds of problems linear, integer, and dynamic optimization have been used to solve.
2. Learn how to develop mathematical models for optimization problems that arise in many different industries and application areas.
3. Be able to identify the special features of a model that make it a linear, integer, or dynamic programming model.
4. Learn how to solve two-variable linear programming models by the graphical solution procedure.
5. Understand the importance of extreme points in obtaining and characterizing the optimal solution to a linear optimization problem.
6. Understand how alternative optimal solutions, infeasibility and unboundedness can occur in linear programming problems.
7. Understand the importance of duality theory in linear programming, such as in sensitivity analysis.
8. Understand how to solve a mathematical optimization by hand or with computer software.

Prerequisite(s): MATH 225 – Linear algebra and linear differential equations

Co-Requisite(s): None

Concurrent Enrollment: None

Recommended Preparation: Basic proficiency with any programming language desired, but not a strict prerequisite.

Course Notes

Students will be responsible for downloading the lecture notes for each lecture from the course website. All handouts, including homework, homework solutions, exams, and exam solutions will be posted in the Brightspace course website. Additional readings and notes beyond the main texts used in the lectures will be provided by the instructor as needed.

Technological Proficiency and Hardware/Software Required

Nothing of note; access to a computer is required.

Required Readings and Supplementary Materials

• Winston, Wayne. *Operations Research: Applications and Algorithms*. Thomsom Brooks/Cole, 2004. [out of print; available online at https://archive.org/details/OperationalResearchWinstonWayne/]

Additional optional course readings may be taken from:

• Badiru, A. B., and O. Omitaomu. *Handbook of Industrial Engineering Equations, Formulas, and Calculations*. CRC Press, 2011. [available online at https://libraries.usc.edu/]

• Eiselt, H. A., and Carl-Louis Sandblom. *Operations Research: A Model-Based Approach*. 2nd edition. Springer, 2012. [available online at https://libraries.usc.edu/]

• Ravindran, A. Ravi. *Operations Research and Management Science Handbook. CRC Press, 2007*. [available online at https://libraries.usc.edu/]

Description and Assessment of Assignments

Grading will be based on problem sets, two take-home midterm exams, and a take-home final exam. We will have 10 problem sets and the lowest score will be dropped. Students may collaborate in groups of two or three on homework, but each student must write up their own assignments. In addition, students must write the names of all collaborators at the heading of each assignment. Assignments and exams are concerned with modelling optimization problems, solving them, and describing their solutions.

Grading Breakdown

Your course grade is 40% problem sets, 40% midterms, and 20% final exam.

Assessment Tool (assignments)	Points	% of Grade
Problem Set 1	10	4
Problem Set 2	10	4
Problem Set 3	10	4
Problem Set 4	10	4
Problem Set 5	10	4
Problem Set 6	10	4
Problem Set 7	10	4
Problem Set 8	10	4
Problem Set 9	10	4
Problem Set 10	10	4
Midterm 1	100	20
Midterm 2	100	20
Final	50	20
TOTAL	200	100

Assignment Submission Policy

Assignments should be submitted via Brightspace before the designated due date.

Grading Timeline

All assignments and exams will be returned to students within two weeks of submission. For each assignment, you have two weeks after receipt in which to request re-grades or corrections.

Additional Policies

None

Course Schedule: A Weekly Breakdown

Provide a detailed course calendar that includes a list of deliverables (homework assignments, examinations, etc.) broken down on a weekly basis. The format may vary, but the content must include:

- Subject matter (topic) or activity
- Required preparatory reading or tasks (e.g., viewing videos)
- Deliverables and when each deliverable is due. A blanket statement that there will be a deliverable due at a specified frequency (e.g., there will be homework due weekly) may obviate the need to state when certain deliverables are due

IMPORTANT:
In addition to in-class contact hours, all courses must also meet a minimum standard for out-of-class time, which accounts for time students spend on homework, readings, writing and other academic activities. Standard fall and spring sessions (001) require a final summative experience during the University scheduled final exam day and time.

	Topics/Daily Activities	**Readings/Preparation**	**Deliverables**
Week 1	Introduction to operations research • The main elements of operations research • Historical examples • Operations research in data science and AI • Terminology	Winston 1 Eiselt & Sandblom 1 "Why operations research is awesome – an introduction", by Alex Elkjær Vasegaard	None
Week 2	Modelling with operations research • Production planning • Diet problems • Allocation problems • Multi-period models • Workforce scheduling • Transportation problems	Winston 2-3 Eiselt & Sandblom 1, 2.1-2.2	None
Week 3	Linear optimization models in data science and AI • Linear regression • Support vector machines	Course notes written by ISE faculty	PS1
Week 4	Solving low-dimensional linear optimization problems • The graphical method for linear programming • Graphical sensitivity analysis • Fourier-Motzkin elimination	Winston 3.1-3.3 Eiselt & Sandblom 2.3-2.4	PS2

Week 5	Solving linear optimization problems with the simplex method • Converting an LP to standard form • Constructing a simplex tableau • Pivoting in a simplex tableau • The big M method • The two-phase simplex method • Karmarkar's method for solving LPs	Winston 4.1-4.13	PS3
Week 6	Solving linear optimization problems with computer software • Excel • CVXPY • Google OR-tools	Winston 4.14-4.17 "Hands-on linear programming: optimization with Python" by Mirko Stojiljković User guide for cvxpy User guide for Google OR-tools	None; practice midterm materials provided but not graded
Week 7	Midterm exam	None	Midterm exam
Week 8	Duality theory • Taking the dual of an LP • Strong and weak duality • Interpreting dual variables	Winston 5 Eiselt & Sandblom 2.5	PS4
Week 9	Duality theory • Sensitivity analysis • Shadow prices • Complementary slackness	Winston 6.1-6.6	PS5
Week 10	Duality theory • The dual simplex method • Dual variables and computer software	Winston 6.7-6.12	PS6
Week 11	Integer programming I • Shortest path problems • Knapsack problems • Matching problems • Critical path analysis	Winston 8, 9.1-9.2	PS7
Week 12	Integer programming II • Binary integer programs and Boolean logic	Winston 9.3-9.5 Eiselt & Sandblom 4	PS8

	• Sudoku • Minesweeper • The "Lights out" game • K-means clustering		
Week 13	Solving integer programs • Branch-and-bound • Implicit enumeration • Cutting plane methods • Constraint programming and computer software	Winston 9.3-9.8 Eiselt & Sandblom 5 The MiniZinc handbook 1-2	PS9
Week 14	Dynamic programming • Shortest path problems • Knapsack problems • Multi-period problems • Formulating dynamic programming recursions	Winston 18	PS10
Week 15	Dynamic programming and AI • Autocorrect and spellcheck with dynamic programming • The "chopsticks" hand game • The "Flip" game • The "Wordle" game	Course notes from ISE faculty "Dynamic programming and board games: a survey" by David K. Smith	None; final exam prep
FINAL	Final exam		Refer to the final exam schedule in the USC *Schedule of Classes* at classes.usc.edu.

Statement on Academic Conduct and Support Systems

Academic Conduct:

Plagiarism – presenting someone else's ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Part B, Section 11, "Behavior Violating University Standards" policy.usc.edu/scampus-part-b. Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on Research and Scholarship Misconduct.

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.

Support Systems:

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

National Suicide Prevention Lifeline - 1 (800) 273-8255 – 24/7 on call
suicidepreventionlifeline.org
Free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week.

Relationship and Sexual Violence Prevention Services (RSVP) - (213) 740-9355(WELL), press "0" after hours – 24/7 on call
studenthealth.usc.edu/sexual-assault
Free and confidential therapy services, workshops, and training for situations related to gender-based harm.

Office for Equity, Equal Opportunity, and Title IX (EEO-TIX) - (213) 740-5086
eeotix.usc.edu
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) 740-5086 or (213) 821-8298
usc-advocate.symplicity.com/care_report
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.usc.edu
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) 821-4710
campussupport.usc.edu
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
diversity.usc.edu
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
dps.usc.edu, emergency.usc.edu
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) 442-120 – 24/7 on call
dps.usc.edu

Non-emergency assistance or information.

Office of the Ombuds - (213) 821-9556 (UPC) / (323-442-0382 (HSC)
ombuds.usc.edu
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) 442-33*40 or otfp@med.usc.edu
chan.usc.edu/otfp
Confidential Lifestyle Redesign services for USC students to support health promoting habits and routines that enhance quality of life and academic performance.