USC Marshall
School of Business

BUAD 313 – Advanced Operations Management and Analytics

Syllabus – Fall 2023 – 4 Units – T/Th – Time(s): 12pm - 1:50pm *or* 2pm - 3:50pm

Version: 11/6/23

Contact Information

Instructor: **Andrew Daw**

Email: **dawandre@usc.edu**

Office Hours:

Standard (BRI 401B and Zoom):	Tuesday's	4:00 – 6:00 pm
	Thursday's	4:00 – 6:00 pm
Roaming (On Campus / Expo. Park):	Wednesday's	3:30 – 4:00 pm

The Zoom link for office hours is available on Blackboard
Note: I want to accommodate as many students as possible, so I would be happy to hold additional office hours based on the students' requests.

Class Schedule: Tuesday and Thursday 12 – 1:50 pm
or Tuesday and Thursday 2 – 3:50 pm (*two sections*)

Course Description: The course will teach advanced techniques in operations management and analytics, focusing on optimization and simulation modeling. You will learn how to make better business decisions under uncertainty through the use of optimization and simulation, and you will see the enormous and impactful applications of optimization and simulation across multiple industries, including aviation, hospitality, retail, supply chain, manufacturing, banking, services, and call centers. This course will teach you the tools and techniques to formulate an optimization model, incorporate uncertainty through simulation, solve the optimization and simulation models, and interpret the resulting solutions. You will gain a unique analytics edge in an increasingly competitive global business environment.

Learning Objectives: You will learn advanced operations analytics, enhance your managerial insights and intuition, and improve your business decisions. The focus of the course is on the Marshall Undergraduate Learning Goals (see the end of the syllabus for a complete description) of "understanding key business areas" and "developing critical thinking skills", while also supporting the goal of "being effective communicators." Upon successful completion of the course, students will master the following learning objectives.

1. Identify and describe business problems and applications where optimization and simulation models are applicable.
2. Translate a complex business problem into an optimization model by identifying appropriate decision variables, writing out the objective function in terms of the decision variables, and developing constraints that capture the underlying business requirements.
3. Describe the optimization model using precise and appropriate mathematical notation.
4. Structure, implement, and solve the optimization model in an Excel spreadsheet, and, possibly with the help of generative AI tools, employ advanced scientific computing packages to expand optimization analysis beyond the standard scope of Excel.
5. Incorporate uncertainty into optimization models through simulations by translating sources of randomness and system dynamics into probabilistic simulation models, leading to precise methods to measure, evaluate, and determine key operational decisions.

6. Translate the uncertainties and dynamics of business processes into simulation models, and use @Risk and other simulation techniques to develop, implement, and evaluate these simulation models.
7. Understand and interpret the solutions of the optimization and simulation models.
8. Extract business insights from the models and provide recommendations for better decisions.

Prerequisites: The class is designed for exceptionally motivated students who want to learn advanced techniques in operations management and analytics. There will be multiple homework assignments, which can be long, complex, and challenging. Students must have completed BUAD 312 or BUAD 310 (with a grade of B+ or better recommended); alternatively, students may have instead completed EE 364 or MATH 407. Students are expected to have access to a laptop and be able to use regularly, efficiently, and effectively a word processor, e-mail, a web browser, and the Excel software. We will frequently use laptops during class, and laptops are required to complete homework and case assignments, possibly along with the midterms and final exam.

This is a course that requires computation: If a student's laptop cannot work with large datasets, please contact the professor immediately to make arrangements. In particular, please see the following options for borrowing laptops from USC:

From USC Libraries: https://itservices.usc.edu/spaces/laptoploaner/
• Mac or PC
• Rent on Hourly Basis for free (4-hour max, can renew in person for more hours.)
• Can come any time the library is open.
• If requested from Professor, Libraries may allow advance reservation, Professor would email ITS Learning environments at spaces@usc.edu for this special request.

IMPORTANT NOTE**:** This class duplicates the credit in BUAD 311. You cannot get credits for this class and BUAD 311. If you already took BUAD 311, you **cannot** take this class. **This course will satisfy the core operations management requirement for Marshall undergraduates.**

Required Materials: You will need access to Excel, and you will need to install the Solver add-on. This is free of charge, and instructions will be provided. We will analyze various external cases, which may require extra purchases. If cost is ever a barrier to you participating in the course, please contact the professor and support will be provided, no questions asked.

There is no official course textbook. You are expected to refer to the class lecture slides and other posted material on Blackboard, such as the @RISK online help manual.

Optional Textbooks: For those wanting additional reading, the following textbook will allow you to go deeper into the course's methodology:

DMD -- Data, Models, and Decisions: The Fundamentals of Management Science by D. Bertsimas and R. M. Freund, 2nd Edition, published by Dynamic Ideas in 2004 (ISBN-13: 978-0975914601 and ISBN-10: 097591460X). The textbook is available at bookstore, or online at Dynamic Ideas through https://www.dynamic-ideas.com/books/ecbcnthsfb6hnzfdezpw0aldtvl9yr
DES -- Discrete-Event System Simulation by Banks, Carson, Nelson, and Nicol (publisher: Prentice Hall)

These are great references, but we will not be following them precisely. They should eb thought of as possibly augmenting your learning, rather than guiding the course.

Instructional Methods: The class will be taught through the following three instructional methods.

Lectures: During the lecture, I will cover key concepts and methodologies, along with simple illustrative examples. The lecture note will be posted on Blackboard.

Problem Solving: There will be around a dozen class sessions where we focus on solving real-world business problems using optimization and simulation models. The problems that we cover in these sessions are often based on *large-scale, challenging, and real-world applications*. These sessions are designed to give student hands-on experience in using optimization and simulation tools to solve complex business problems. In many of sessions, we will also work together in-class to write code.

In-class Activities: These in-class activities will provide students with firsthand experience of the versatility of the models and techniques used in optimization and simulation. The experiential learning will be done through games, role plays, sports, and illustrations.

Grading Policies: The course grade will be curved and based on class participation, preparation and effort during problem solving sessions, homework and case assignments, midterms, and a cumulative final exam, according to the following weights:

Class Participation	10%
Problem Solving Sessions	5%
Assignments	35%
Exams (Midterm and Final)	50%

Class Participation: It is very important for each student to actively participate in the class discussion. Read the assigned material before the class and make sure you are familiar with the main issues to be discussed in class. You will be cold-called. Your participation is evaluated mainly on the quality of your contribution and insights. I will make every effort to call on as many students who wish to speak up as possible.

Participation points will be announced and updated on Blackboard throughout the semester; roughly coinciding with the times of assignments or exams. These scores will be out of 10 points, and *they will only increase or stay the same* as the semester progress. For example, if a student has a participation score of 5 after the midterm (which would be good, at that point in time) and then never shows up to class again, does not participate in any online discussions (such as Slack), never comes to office hours, and generally just disappears from BUAD 313, they would still have a 5 for the participation score at the end of the semester (which would be less good).

Problem Solving Sessions: There are a number of problem-solving sessions during the semester. These sessions are important in consolidating your understanding of optimization models, sharpening your ability to apply optimization and simulation techniques to business applications, and improving your overall problem solving skill set. Each student is expected to attend all problem-solving sessions; attendance will be taken through the form of wrap-up questions at the end of each session. Each student will be given a handout with a detailed description of the business problem in advance (on Blackboard), and before coming to the class, each student is expected to have read the problem description and attempted to formulate an optimization or simulation problem. Each student is expected to fully participate in these activities.

Assignments: During the course, you will be given 6 assignments. Rather than dropping one assignment, the average will be taken over 5 assignments (but no more than 100% of the points will be awarded). This means that, for individual assignment percentage scores A_1, A_2, A_3, A_4, A_5, and A_6, the overall score will be

$$\boldsymbol{A_{\text{total}} = \min\{100\%, (A_1 + A_2 + A_3 + A_4 + A_5 + A_6)/5\}.}$$

The intention of this scoring structure is to incentivize you to put at least some effort into all assignments throughout the course, while also recognizing that life's personal circumstances don't always follow the calendar of the academic semester, which may present significant challenges and obstacles at any point in the semester. This policy is designed for flexibility and respects student's ability to manage their own time. Thus, exceptions

outside of it will be quite seldom; it may be likely that no further exceptions will be granted in a given semester across all sections of the course. Nevertheless, if you are faced with a particularly severe dilemma, please contact me and utilize the many available resources of support described in the following section.

Students must complete the assigned readings, homework assignments, and case studies prior to coming to class. Assignments are due on the indicated due date before the start of the class and no late work will be accepted. You can work on the cases and assignments individually or in a team. ***Unless otherwise stated for a given assignment,*** each team will consist **of at most 2 students**. *Please check the assignment details on Blackboard for the precise team size rules*. Three of the assignments (Assignments #2, #3, and #5) will involve case questions. On these assignments, I will ask students to present their results to the class.

Exams: We have two exams in the course: a midterm and a final exam. We will give more weight to the exam with the higher score. The overall score for the exam will be computed based on the following formula:

60% x (maximum score between the two exams) + 40% x (minimum score between the two exams)

Regrade policy: Regrade requests must be submitted via email no later than three weeks from when the assignment grade was returned. Students should be advised that regrading is handled by the professor, rather than the original grader, and the professor regrades the entire assignment, not just one part. Hence, ***it is possible that scores may actually decrease upon regrading.*** Students should consider this possibility when deciding whether to request a regrade or not. Only the exams and assignments are open to regrading.

Makeup Exams: Makeup exams are allowed for "documented medical emergencies". The students need to provide proper documentations by the time of the exam, including (a) a signed doctor's note, with the name and phone number of the medical professional verifying the medical emergency and (b) an email from the student's Marshall advisor.

Course Disclaimer: This syllabus is an invitation to students to engage in an exciting and interactive study of optimization and simulation. The intention of the instructor is to provide you with information, offer practice with skill sets, and enhance your capacity to use fundamental concepts to build your repertoire of optimization and simulation tools and make sound decisions. The learning environment will be collaborative and supportive; we will learn from one another both in and out of the classroom. To that end, modifications to this syllabus may be warranted as determined by the instructor as we assess the learning needs of this particular class of students. In addition, grades for class participation and problem-solving sessions are under the sole discretion of the instructor.

Responsibility and ownership of work: While teamwork is allowed on assignments and group study is encouraged (and shown to be a significant boost to your learning!), each student is individually responsible for the accuracy and legitimacy of their work. Sound reasoning should be given for each problem solution, and students may be asked to explain further. This applies to solutions developed with classmates but also to the use of advanced toolkits, such as those based on generative AI (ChatGPT, GitHub CoPilot, etc). ***Depth of understanding is a prerequisite to any submission, and all aids must be properly acknowledged.*** In summary, students are fully responsible for all submitted work.

Academic Conduct, Learning Environment, 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.

Open Expression and Respect for All: An important goal of the educational experience at USC Marshall is to be exposed to and discuss diverse, thought-provoking, and sometimes controversial ideas that challenge one's beliefs. In this course we will support the values articulated in the USC Marshall "Open Expression Statement."

Students with 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
sites.google.com/usc.edu/counseling-mental-health
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
988lifeline.org
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 is comprised 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
sites.google.com/usc.edu/rsvpclientservices/home
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
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) 740-0411
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
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) 442-1200 – 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) 442-2850 or otfp@med.usc.edu
chan.usc.edu/patient-care/faculty-practice
Confidential Lifestyle Redesign services for USC students to support health promoting habits and routines that enhance quality of life and academic performance.

COURSE OUTLINE

The pictures next to each session describe the instructional methods used in the session, where  denotes lectures,  denotes problem solving sessions, and  denotes in-class activities. The relevant learning objectives (#1 - #8) are listed on the first page of the syllabus. Selected key operations management topics are highlighted for each new material session; some topics can and will appear across multiple sessions, even if not listed.

Session 1 – 8/22/23 (Tuesday)  : Introduction to operations management. Understanding process analysis, capacity, utilization, and process analysis.
Question: What is operations management (OM)? Why do we study OM?
Outline: You will discover that OM defines business competitiveness and that the study of OM prepares you to become business leaders and entrepreneurs by qualitatively and quantitatively assessing trade-offs. You will learn how the flow of customers or products into and out of a system determines process measures and profit.
Topics: business processes, resources, bottlenecks, flow rate, capacity, utilization, performance metrics, tradeoffs
Learning outcomes: By the end of the session, you will be able to

- Define and identify Operations Management problems in real-world situations
- Construct and interpret business processes using process flow diagrams
- Calculate key performance measures of a process, including capacity, flow rate, and utilization rate
- Define flow time and work-in-process
- Identify the bottleneck that governs the capacity of a process

Relevant learning objectives: **#1**, **#2**

Session 2 – 8/24/23 (Thursday)  : Kristen's Cookie Company
Question: What is the makeup of a small cookie business? How do we determine the capacity of a process?
Outline: Through this case, you will gain a better understanding of the business profitability through business process analysis; you will evaluate key performance measures under different sales mixes, and recognize the impact of the bottleneck on price and profit.
Topics: small businesses, flow time, time-to-order-completion, total-orders-by-time, cross-training, pricing
Learning outcomes: Through this case, students should be able to

- Conduct business process analysis to assess business profitability
- Evaluate key performance measures under different sales mixes
- Quantify the impact of the bottleneck on price and profit

Relevant learning objectives: **#1**, **#2**

Reading: The Kristen's Cookie Company case on Blackboard

Session 3 – 8/29/23 (Tuesday)  : Introduction to linear optimization
Question: What is linear optimization?
Outline: You will discover linear programming (LP), which is one of the most common tools used in operations analytics. Through a hands-on in-class activity, you will see how LP can be used to help you make better decisions. We will also introduce a simple application of LP in online advertising.
Topics: online advertising, linear programming, objective functions, decision variables, constraints
Learning outcomes: By the end of the session, you will be able to

- Formulate a linear program (LP) and solve small LP problems using Excel Solver.
- Understand the components of a linear program

Relevant learning objectives: **#1**, **#2**

Session 4 – 8/31/23 (Thursday)  : Application of LP's to product blending
Question: How can we use LP to determine the optimal blend of products?
Outline: During the class, we will work through a case and formulate an LP to find the most profitable blend given the raw material constraints. You will acquire hands-on experience in formulating a complex LP to maximize profitability, using actual data from a business operation.
Topics: profit maximation, data-driven decisions, optimal solution, optimal value
Learning outcomes: By the end of the session, you will be able to

- Formulate complex LP to optimize business operations
- Structure complex LP in Excel
- Interpret the Excel outputs for business insights

Relevant learning objectives: **#1**, **#2, #3,**
Reading: Handout on Blackboard

**** 9/5/23: Assignment #1 is due. ****

Session 5 – 9/5/23 (Tuesday)  : Sensitivity analysis in linear optimization
Question: How does the objective value of a linear program change with the problem parameters?
Outline: Through an in-class activity, you will experience how LP can be used to determine the optimal product mixture? You will also learn how to use the sensitivity report to handle uncertain in the problem parameters.
Topics: product and production management, sensitivity report, shadow price, allowable increase and decrease
Learning outcomes: By the end of the session, you will be able to

- Construct advanced LP formulation
- Understand how to use the sensitivity report
- Explain the impact of changes in the problem's parameters
- Understand the concept of shadow prices
- Interpret the sensitivity report generated by Excel Solver

Relevant learning objectives: **#7, #8**

Session 6 – 9/7/23 (Thursday)  : Solving Large Problems in Python w/ the Gurobi package and Github CoPilot
Question: How do we solve LP problems that are too big for Solver in Excel, and how can generative AI tools help us do this?
Outline: Many real-world optimization problems are quite large, meaning they have many variables and many constraints. Excel's Solver plug in limits the number of constraints, so we must use other methods. A leading

toolkit in practice is the Gurobi package, which contains commercial optimization software. Thanks to recent advances in generative AI, there is now broad access to tools with cutting-edge capability.
Topics: large-scale decision problems, optimization, Gurobi, generative AI
Learning outcomes: By the end of the session, you will be able to

- Understand the limits of Excel Solver and identify when it is (or is not) the appropriate solution technique
- Use Github CoPilot (and/or other generative AI tools) to model, solve, and assess the sensitivity of large optimization problems in Python using the Gurobi package

Relevant learning objectives: **#3**, **#4, #8**

Session 7 – 9/12/23 (Tuesday)  : Additional examples of large LP problems
Question: How do we solve LP problems that are too big for Solver in Excel, and how can generative AI tools help us do this?
Outline: Many real-world optimization problems are quite large, meaning they have many variables and many constraints. Excel's Solver plug in limits the number of constraints, so we must use other methods. A leading toolkit in practice is the Gurobi package, which is commercial optimization software. Thanks to recent advances in generative AI, there is now broad access to tools with cutting-edge capability.
Topics: large-scale decision problems, optimization, Gurobi, generative AI
Learning outcomes: By the end of the session, you will be able to

- Understand the limits of Excel Solver and identify when it is (or is not) the appropriate solution technique
- Use Github CoPilot (and/or other generative AI tools) to model, solve, and assess the sensitivity of large optimization problems in Python using the Gurobi package

Relevant learning objectives: **#4, #7, #8**

Session 8 – 9/14/23 (Thursday)  : Introduction to discrete optimization
Question: Can we apply optimization tools when the decision variables are not divisible?
Outline: Optimization is more than linear programming. The firms cannot hire half of a person or fly a quarter of an airplane. Through an in-class activity and a simple capital budgeting problem, you will learn how to extend linear optimization model to setting when decision variables are discrete.
Topics: discrete decision variables, binary and integer programming, capital management
Learning outcomes: By the end of the session, you will

- Understand the components of an integer program (IP)
- Formulate an IP and solve it using Excel solver and/or other tools
- Understand how to use binary decision variables to model constraints in integer programming

Relevant learning objectives: **#1**, **#2, #3**

**** 9/19/23: Assignment #2 (Filatoi Riuniti Case) is due. ****

Session 9 – 9/19/23 (Tuesday): Filatoi Riuniti Case presentation by students
Question: How can Filatoi Riuniti use LP's to optimize their yarn productions and make other strategic business decisions?
Outline: We will discuss your solution approaches to the Filatoi Riuniti case, identify key business insights from the optimization models, and explore additional business questions that can be answered through optimization.
Topics: textiles, production, revenue management, acquisitions, outsourcing
Learning outcomes: By the end of the session, you will

- Learn how to formulate linear program to help companies optimize their production operations.
- Learn about outputs of LP and sensitivity report can be used to help in setting prices, determining capacity expansion, and evaluating strategic acquisition opportunities.
- Formulate an LP for a production planning problem
- Use sensitivity report to analyze business opportunities

Relevant learning objectives: **#3, #4, #7, #8**

Session 10 – 9/21/23 (Thursday)  : The (Optimal) Dream Team: IPs for the Team USA Basketball Roster
Question: How can we use IPs to optimize the selection of players when forming a basketball team?
Outline: Using the integer programming skills we have gained in the preceding sessions, we will return to the Kristen's Cookies case to ask deeper questions and improve upon our prior decisions.
Topics: roster formation, binary/integer decisions, flexibility/versatility
Learning outcomes: By the end of the session, you will

- Identify problems that can be formulated as an IP
- Express yes/no decisions as binary variables and capture mutually exclusive choices in constraints
- Model (general) team formation as an IP and solve for the optimal personnel

Relevant learning objectives: **#1**, **#2, #3**

Session 11 – 9/26/23 (Tuesday)  : Discrete optimization for corporate restructuring
Question: How can we use discrete optimization to develop a plan to either invest in, maintain, or sell the various divisions within our enterprise?
Outline: Discrete optimization can be used to develop a plan to focus resources on the best collection of divisions.
Topics: workforce management, corporate planning, succession, first best solution
Learning outcomes: By the end of the session, you will

- Formulate an integer program (IP) to determine the schedule for workers
- Express scheduling and business constraints using linear functions

Relevant learning objectives: **#1, #2, #3, #4**

Session 12 – 9/28/23 (Thursday)  : Discrete optimization in finding the best volume discounts
Question: How can we use discrete optimization to identify the best volume discounts?
Outline: The market for mobile phones has reached saturation. To reduce cost, mobile phone operators must decide how to allocate phone calls to carriers in most cost-efficient fashion. You will have an opportunity to apply integer programming to identify the best strategy for obtaining volume discounts, which is based on an actual business problem.
Topics: telecommunication, provider networks, volume discounts, cost minimization
Learning outcomes: By the end of the session, you will

- Learn how to formulate a discrete optimization problem to identify the optimal volume discount
- Set up the code/spreadsheet for complex integer programs.

Relevant learning objectives: **#1**, **#2, #3, #4, #5, #6, #7**
Reading: "Selecting Telecommunication Carriers" case on Blackboard.

Session 13 – 10/3/23 (Tuesday)  : Continued examples of discrete optimization
Question: How can we use discrete optimization to make non-continuous decisions?
Outline: In this class, we will wrap up the examples from the previous sessions, and possibly add new ones as time allows.
Topics: workforce management, corporate planning, succession, first best solution, telecommunication, provider networks, volume discounts, cost minimization
Learning outcomes: By the end of the session, you will

- Formulate an optimization problem with discrete variables
- Express scheduling and business constraints using linear functions
- Implement complex discrete optimization models to obtain numerical solutions

Relevant learning objectives: **#1**, **#2, #3, #4, #5, #6, #7**

**** 10/5/23: Assignment #3 (Portfolio Optimization Case) is due before the class starts.**

Session 14 – 10/5/23 (Thursday): Review for Midterm
Session 15 – 10/10/23 (Tuesday): Midterm (in class)

NOTE: I will have extra office hours on Thursday (10/5), Friday (10/6) and Monday (10/9) to help with the midterm preparation.

Session 16 – 10/12/23 (Thursday): **NO CLASS --- University Holiday (Fall Break)**

Session 17 – 10/17/23 (Tuesday)  : Decision making under uncertainty through decision trees
Question: How do we optimize our decisions in the face of uncertainty? What is a decision tree?
Outline: The decision tree is a schematic model to manage uncertainty by clearly identifying alternative choices. You will learn how to construct a decision tree — its nodes and branches — and solve for the optimal decision.
Topics: uncertainty, decision trees, expected value, multi-period decision-making
Learning outcomes: By the end of this section, you will be able to

- Use decision trees to express alternative choices and to manage uncertainty
- Described differences between the three types of nodes in the decision trees
- Solve decision tree problems

Relevant learning objectives: **#5**

Session 18 – 10/19/23 (Thursday)  : Dealing with continuous distributions through simulation
Question: How to make effective decisions in face of continuous random variables?
Outline: Decision trees are designed for problems with discrete uncertainties. Through an AppShop case, you will learn how to make effective decisions under continuous random variables through simulation. We will show how to simulation random variables in Excel using the inversion method.
Topics: continuous random variables, simulation, project management
Learning outcomes: By the end of this section, you will be able to

- Formulate an optimization problem in face of continuous uncertainties
- Use Excel to simulation random numbers from various probability distributions
- Solve decision tree problems with continuous random variables using simulations

Relevant learning objectives: **#5, #7**
Reading: The AppShop Case (on Blackboard)

Session 19 – 10/24/23 (Tuesday)  : Continued examples: AppShop case wrap-up and project management
Question: How to make effective decisions in face of continuous random variables?
Outline: Decision trees are designed for problems with discrete uncertainties. Through an AppShop case, you will learn how to make effective decisions under continuous random variables through simulation. We will show how to simulation random variables in Excel using the inversion method.
Topics: continuous random variables, simulation, project management
Learning outcomes: By the end of this section, you will

- Formulate an optimization problem in face of continuous uncertainties

- Use Excel to simulation random numbers from various probability distributions
- Solve decision tree problems with continuous random variables using simulations

Relevant learning objectives: **#5, #7**

**** 10/26/23: Assignment #4 is due before the class starts.**

Session 20 – 10/26/23 (Thursday) : Beyond Excel simulations
Question: How can we leverage the structure of Monte Carlo simulations using Python?
Outline: Through several examples, including a newsvendor problem with correlated demand, we will show how to perform Monte Carlo simulation using Python.
Topics: newsvendor model, inventory management, (in)dependent random variables, Monte Carlo simulation
Learning outcomes: By the end of this section, you will

- Learn the basic loop structure of simulation experiments and connect this to Python
- Generate summary statistics and histograms of outputs

Relevant learning objectives: **#5, #7**

Session 21 – 10/31/23 (Tuesday) : Application of Simulation to Revenue Management
Question: How can we use simulations to help airlines make better operational decisions?
Outline: Through a BlueSky Airlines case, we will discuss how we can set up complex simulation models to help an airline determine the best booking limit in order to maximize its expected revenue?
Topics: airline revenue management, pricing, capacity control
Learning outcomes: By the end of this section, you will

- Understand the essential of revenue management, particularly in the airline industry
- Create complex simulation models
- Use simulation models to generate insights about the underlying business problems

Relevant learning objectives: **#5, #7**
Reading: The BlueSky Airlines case

Session 22 – 11/2/23 (Thursday) : Introduction to Markov Chains: Randomness across time
Question: How should we model businesses process that involve systems which evolve randomly across time?
Outline: We will introduce the concept of Markov chains, where the distribution state of the system at the next point in time depends on the state of the system at the current point in time.
Topics: stochastic process, Markov property, finite-state, irreducibility
Learning outcomes: By the end of this section, you will

- Understand how to model a process random state-dependent transitions as a Markov chain
- Describe conditions under which the Markov chain model will or will not exhibit long-term behavior

Relevant learning objectives: **#5, #7, #8**

Session 23 – 11/7/23 (Tuesday) : Markov Chains I: Absorption Analysis
Question: What happens to random processes before they reach a terminal state?
Outline: Through motivating examples in the spread of information, innovation, and disease, we will simulate and analyze Markov chain models that represent processes destined for an eventual convergence to a sub-state
Topics: compartmental models, diffusion of innovations, basic reproduction number
Learning outcomes: By the end of this section, you will

- Use Markov chains to model concepts like contagion and virality and simulate their impacts
- Identify key insights from the simulation models across a variety of application areas

Relevant learning objectives: **#5, #6, #7, #8**

Session 24 – 11/9/23 (Thursday)  : Markov Chains II: Steady-State Analysis
Question: What is a "steady state" and how long does it take to get there?
Outline: Through an example model from inventory management, we will motivate the concept of "steady state" and equilibrium distributions of Markov chains. Through simulation, we will analyze how quickly the process reaches this distributional equilibrium.
Topics: transience, recurrence, mixing time, re-order point, economic order quantity
Learning outcomes: By the end of this section, you will

- Understand how to incorporate uncertainties in business processes using simulation
- Evaluate performance measures from simulation

Relevant learning objectives: **#6, #7, #8**

**** 11/14/23: Assignment #5 is due before the class starts.**

Session 25 – 11/14/23 (Tuesday): Assignment 5 case presentation by students
Question: How can Markov chains be used to model business questions, and how should they inform our decisions?
Outline: Through this assignment on customer lifetime value analysis, you will develop a Markov chain model of the described scenario, and you will pitch the resulting analysis to your classmates and to the teaching team.
Topics: comparisons of Markov chain modeling, randomness through time, marketing, customer relationship management
Learning outcomes: By the end of this section, you will

- Learn to use simulation to evaluate different business strategies
- Represent business challenges in a Markov chain model
- Present model analysis and findings to an audience of stakeholders

Session 26 – 11/16/23 (Thursday)  : Introduction to Queueing Models, Little's Law, and the M/M/s Queue
Question: How does waiting impact business operations, and what is a queueing model?
Outline: We will discuss key queueing characteristics (arrival patterns, service discipline, service distributions), and the exponential distribution. We will also introduce important queueing relationship including Little's Law. We will also discuss basic performance measures for M/M/s queue.
Topics: queues, service operations, Kendall notation, flow time, flow rate, work-in-progress, waiting line management
Learning outcomes: By the end of this section, you will

- Understand the elements of queueing model
- Understand the memoryless property of the exponential distribution
- Link various performance measure using Little's Law
- Understand properties of M/M/s queue

Relevant learning objectives: **#6, #7, #8**

Session 27 – 11/21/23 (Tuesday)  : Simulating and staffing queueing models under general distributions
Question: How do we determine queueing performance measures when the interarrival and service times are not exponentially distributed? How can we use the queueing simulation models we have developed to determine optimal staffing levels for service systems with time-varying demand?
Outline: We will discuss how to build a queueing simulation model that allows for general interarrival and service time distributions. Our simulation model will track the events within the queue and allow us to assess performance. We will use our queueing model knowledge and simulation skills to implement an iterative staffing algorithm.

Through an application to real world data, we will calculate the requisite staffing levels needed to achieve target levels of service quality while managing demand flows that vary across time.
Topics: general arrival and service processes, measures of variation, over-dispersion, service staffing, time-varying demand, call centers, iterative staffing algorithm
Learning outcomes: By the end of this section, you will

- Understand the logic for building a general queueing simulation model
- Identify the operational challenges created by time-varying arrival rates
- Explain and implement the iterative staffing algorithm

Relevant learning objectives: **#6, #7, #8**

Session 28 – 11/23/23 (Thursday): **NO CLASS --- University Holiday (Thanksgiving)**

Session 29 – 11/28/23 (Tuesday)  : Optimization meets Simulation: Stochastic Linear Programs
Question: How should we make decisions under limited resources *and* uncertainty?
Outline: We will combine knowledge gained from across this semester to build a model that draws upon both simulation and optimization techniques. In particular, we will use simulation as a methodology to approach a constrained optimization problem with randomness in its objective and/or constraints.
Topics: stochastic linear programs, sample average approximation, recourse, two-stage linear program
Learning outcomes: By the end of this section, you will

- Understand how to incorporate discrete uncertainty into a linear program
- Create a simple two-stage linear program
- Identify key business insights from the simulation and optimization model

Relevant learning objectives: **#6, #7, #8**

**** 11/29/23: Assignment #6 is due. ****

Session 30 – 11/30/23 (Thursday): Review for the Final Exam

Following the university schedule, the final exam is on December 7 at 8:00 am.

Note that the exam time follows the BUAD 311/313 "Exception" schedule, not the time-of-class schedule.

No early finals are allowed by University policy.

A summary of the class schedule and due dates are given on the next two pages.

Summary of the Schedule of Classes

Week	Session	Date	Topics and Instructional Methods	Activities to Complete before Coming to Class and Assignments Due
1	01	T 08/22	What is OM?: Understanding capacity, utilization, and process analysis 	
	02	Th 08/24	Application of process analysis: Kristen's Cookie Case 	Study the Kristen's Cookie case before coming to class
2	03	T 08/29	Introduction to linear optimization 	
	04	Th 08/31	Linear optimization applications 	Study the case reading on Blackboard before coming to class
3	05	T 09/05	Sensitivity analysis in linear optimization 	**Assignment #1 is due**
	06	Th 09/07	Solving Large Problems in Python with the Gurobi package and Github CoPilot 	
4	07	T 09/12	Additional examples of large LP's 	
	08	Th 09/14	Introduction to discrete optimization (DO) 	
5	09	T 09/19	Case presentation by students (Filatoi Riuniti)	**Assignment #2 (Filatoi Riuniti Case) is due**
	10	Th 09/21	DO application: The (Optimal) Dream Team: IPs for the Team USA Basketball Roster 	
6	11	T 09/26	DO application: Corporate Restructuring 	
	12	Th 09/28	DO application: Optimal volume discounts 	Study the "Selecting Communication Carriers" case before coming to class
7	13	T 10/03	DO applications continued 	
	14	Th 10/05	Review for Midterm	**Assignment #3 (Portfolio Opt.) is due**
8	15	T 10/10	Midterm Exam	
	16	Th 10/12	**NO CLASS – Fall Break ☺**	

9	17	T 10/17	Modeling uncertainty: Decision making under uncertainty through decision trees 	
	18	Th 10/19	Why simulation?: Dealing with continuous distributions through simulation 	Study the AppShop case before coming to class
10	19	T 10/24	Continued simulation examples: AppShop wrap-up and project management 	
	20	Th 10/26	Beyond Excel simulations 	**Assignment #4 is due** (*Participation score [out of 6] update at end of week)*
11	21	T 10/31	Simulation application: Revenue management at BlueSky Airlines 	Study the BlueSky Airlines case before coming to class
	22	Th 11/02	Introduction to Markov Chains 	
12	23	T 11/07	Markov Chains I: Absorption analysis 	
	24	Th 11/09	Markov Chains II: Steady-state analysis 	
13	25	T 11/14	Case presentation by students (Assignment 5: Subscription analysis)	**Assignment #5 is due**
	26	Th 11/16	Introduction to queueing models, Little's Law, and the M/M/s queue 	(*Participation score [out of 9] update at end of week)*
14	27	T 11/21	Staffing and simulating queues under general interarrival and service time 	
	28	Th 11/23	**NO CLASS – Thanksgiving Break ☺**	
15	29	T 11/28	Simulation meets optimization: Stochastic linear programs 	
	30	Th 11/30	Review for final exam	**Assignment #6 is due** (*Participation score [out of 10] update at end of week)*
Final Exam: December 7, 8:00 am				

Contribution of BUAD313: Advanced Operations Management and Analytics to Student Achievement of Marshall's Six Undergraduate Program Learning Goals			
#	**Marshall Program Learning Goal Description**	**Degree of Emphasis**	**BUAD313 Course Objectives that Support Marshall Undergraduate Goals**
1	**Our graduates will understand types of markets and key business areas and their interaction *to effectively manage different types of enterprises.* Specifically, students will:**	**High**	**BUAD313 Course Objectives 1-8 support Goal #1**
1.1	Demonstrate foundational knowledge of core business disciplines, including business analytics and business economics.		1. Recognize how optimization and simulation models interface with other functional areas 2. Analyze trade-offs in decision-making 5. Incorporate uncertainties in operational decisions 8. Understand the broad range of applications of optimization and simulation
1.2	Understand the interrelationships between functional areas of business so as to develop a general perspective on business management.		1. Recognize how optimization and simulation models interface with other functional areas 2. Analyze trade-offs in decision-making 5. Incorporate uncertainties in operational decisions 7. Articulate the business implications of optimization and simulation models 8. Understand the broad range of applications of optimization and simulation
1.3	Apply theories, models, and frameworks to analyze relevant markets (e.g. product, capital, commodity, and factor and labor markets).		2. Analyze trade-offs in decision-making 3. Describe optimization models rigorously 5. Incorporate uncertainties in operational decisions 7. Articulate the business implications of optimization and simulation models 8. Understand the broad range of applications of optimization and simulation
1.4	Show the ability to utilize technologies (e.g., spreadsheets, databases, software) relevant to contemporary business practices.		4. Implement optimization models via Solver or code 5. Incorporate uncertainties in operational decisions 6. Write code to develop simulation models
2	**Our graduates will develop a global business perspective. They will understand how local, regional, and international markets, and economic, social and cultural issues impact business decisions *so as to anticipate new opportunities in any marketplace***	**Low**	**BUAD313 Course Objectives 1, 2, 5, 7, and 8 support Goal #2**
2.1	Understand how local, regional and global markets interact and are impacted by economic, social and cultural factors.		1. Recognize how optimization and simulation models interface with other functional areas 8. Understand the broad range of applications of optimization and simulation

2.2	Understand that stakeholders, stakeholder interests, business environments (legal, regulatory, competitor) and business practices vary across regions of the world.		1. Recognize how optimization and simulation models interface with other functional areas 2. Analyze trade-offs in decision-making 5. Incorporate uncertainties in operational decisions 7. Articulate the business implications of optimization and simulation models 8. Understand the broad range of applications of optimization and simulation
3	**Our graduates will demonstrate critical thinking skills *so as to become future-oriented decision makers, problem solvers and innovators.* Specifically, students will:**	**High**	**BUAD313 Course Objectives 1-8 support Goal #3**
3.1	Understand the concepts of critical thinking, entrepreneurial thinking and creative thinking as drivers of innovative ideas.		1. Recognize how optimization and simulation models interface with other functional areas 2. Analyze trade-offs in decision-making 3. Describe optimization models rigorously 4. Implement optimization models via Solver or code 5. Incorporate uncertainties in operational decisions 6. Write code to develop simulation models 7. Articulate the business implications of optimization and simulation models
3.2	Critically analyze concepts, theories and processes by stating them in their own words, understanding key components, identifying assumptions, indicating how they are similar to and different from others and translating them to the real world.		1. Recognize how optimization and simulation models interface with other functional areas 2. Analyze trade-offs in decision-making 3. Describe optimization models rigorously 5. Incorporate uncertainties in operational decisions 7. Articulate the business implications of optimization and simulation models
3.3	Be effective at gathering, storing, and using qualitative and quantitative data and at using analytical tools and frameworks to understand and solve business problems.		1. Recognize how optimization and simulation models interface with other functional areas 4. Implement optimization models via Solver or code 5. Incorporate uncertainties in operational decisions 6. Use @Risk and code to develop simulation models 8. Understand the broad range of applications of optimization and simulation
3.4	Demonstrate the ability to anticipate, identify and solve business problems. They will be able to identify and assess central problems, identify and evaluate potential solutions, and translate a chosen solution to an implementation plan that considers future contingencies		1. Recognize how optimization and simulation models interface with other functional areas 2. Analyze trade-offs in decision-making 3. Describe optimization models rigorously 5. Incorporate uncertainties in operational decisions 7. Articulate the business implications of optimization and simulation models 8. Understand the broad range of applications of optimization and simulation
4	**Our graduates will develop people and leadership skills to promote their effectiveness as *business managers and leaders.* Specifically, students will:**	**Moder ate**	**BUAD313 Course Objectives 1, 2, 5, 7, and 8 support Goal #4**
4.1	Recognize, understand, and analyze the motivations and behaviors of stakeholders inside and outside organizations (e.g., teams, departments, consumers, investors, auditors).		1. Recognize how optimization and simulation models interface with other functional areas 2. Analyze trade-offs in decision-making
4.2	Recognize, understand and analyze the roles, responsibilities and behaviors of effective managers and leaders in diverse business contexts e.g., marketing, finance, accounting.		1. Recognize how optimization and simulation models interface with other functional areas 7. Articulate the business implications of optimization and simulation models

			8. Understand the broad range of applications of optimization and simulation
4.3	Understand factors that contribute to effective teamwork.		2. Analyze trade-offs in decision-making 5. Incorporate uncertainties in operational decisions
5	**Our graduates will demonstrate ethical reasoning skills, understand social, civic, and professional responsibilities *and aspire to add value to society.* Specifically, students will:**	**Low**	**BUAD313 Course Objectives 1, 2, and 8 support Goal #5**
5.1	Understand professional codes of conduct.		1. Recognize how optimization and simulation models interface with other functional areas 8. Understand the broad range of applications of optimization and simulation
5.2	Recognize ethical challenges in business situations and assess appropriate courses of action.		1. Recognize how optimization and simulation models interface with other functional areas 2. Analyze trade-offs in decision-making 8. Understand the broad range of applications of optimization and simulation
6	**Our graduates will be effective communicators *to facilitate information flow in organizational, social, and intercultural contexts.* Specifically, students will:**	**Moderate**	**BUAD313 Course Objectives 1, 7, and 8 support Goal #6**
6.1	Identify and assess diverse personal and organizational communication goals and audience information needs		1. Recognize how optimization and simulation models interface with other functional areas 8. Understand the broad range of applications of optimization and simulation
6.2	Understand individual and group communications patterns and dynamics in organizations and other professional contexts		1. Recognize how optimization and simulation models interface with other functional areas 7. Articulate the business implications of optimization and simulation models
6.3	Demonstrate an ability to gather and disseminate information and communicate it clearly, logically, and persuasively in professional contexts.		1. Recognize how optimization and simulation models interface with other functional areas 7. Articulate the business implications of optimization and simulation models 8. Understand the broad range of applications of optimization and simulation