IE 8030 Engineering Optimization and Applications
Fall 2020 Course Syllabus

COVID-19 Introduction

Communications and Flexibility: During this unprecedented time, I want to emphasize that my core teaching philosophy will be centered around open communications and flexibility. I realize that your work in this class may be impacted by a variety of circumstances surrounding the stress the pandemic has placed on all of us and I will do my best to be flexible (within reason) so that this course retains its value to you. Please feel free to openly communicate with me about concerns you may have about the class and your performance in it.

In the spirit of open communications, I will state that this is my first semester at Clemson University and I am still learning many of its systems (e.g., we used Blackboard instead of Canvas and WebEx instead of Zoom where I used to teach). Therefore, if I say something is available on Canvas and it is not, please let me know. Note that I have tried to design the delivery of the course to retain flexibility (e.g., asynchronous lectures with 'synchronous' problem sessions).

Basic Information

Instructor: Thomas C. Sharkey, Professor, Department of Industrial Engineering

Instructor Homepage: https://sites.google.com/view/tcshark

E-mail: tcshark@clemson.edu

E-mail Policies: I will do my best to respond to your emails within 1 business day (i.e., do not expect a response over the weekend) of the inquiry. If you do not receive a response by then, please feel free to resend the email.

Office: 263 Freeman Hall (optimistically hoping to have hybrid office hours)

Instructor's Office Hours: MW 11:00 a.m. – 12:00 p.m.

Class Schedule: MWF 10:10 a.m. – 11:00 a.m.

Classroom: Martin-M102 (optimistically hoping for hybrid teaching)

Zoom Classroom: Access to the Zoom Meeting is available through the Canvas site for this class. Note that I plan on recording these meetings and making them available to the class through the "Cloud Recordings" tab.

Official Course Description: Introduction to optimization through the study of problems related to the planning, design and control of production/manufacturing systems; formulation and solution techniques for linear programming problems; the simplex method, theory and computation; duality and sensitivity analysis.

Course Learning Objectives: This course aims to provide students with:

1. An ability to apply commonly used optimization methods to aid decision-making in the context of production, human, and service systems. This includes a conceptual understanding of these methods and how to use software to implement them and provide solutions and analysis.
2. An ability to formulate real-world problems as optimization models.
3. An ability to assess the applicability and limitations of optimization models to a practical problem.

Course Delivery

Course Delivery Structure: The course will be a combination of asynchronous lectures and synchronous "problem sessions" delivered through Zoom and in-person *during our scheduled class hours*. This structure will hold during both the first 4 weeks online and the remainder of the semester.

Asynchronous Lectures: The plan for these lectures is to cover a topic which will then be reinforced through an accompanying "problem session" during class. My expectation is that the lecture will involve 1 to 3 different small videos where the total amount of time for all videos for a lecture is no more than 25-30 minutes. It is my expectation that you will view these lectures *prior* to the accompanying problem session (if you plan on participating in the problem session – which is not required).

Asynchronous Lecture Availability Schedule: The asynchronous lectures will be posted on the following schedule: Lectures for Monday's problem session (class) will be available by the Friday before, Wednesday's class will be available the Monday before, and Friday's class will be available the Wednesday before.

Problem Sessions: Along with the lecture, I will post a problem we will work through as a class during each official class session which is the "problem session" for that lecture. I would ask that you read the problem prior to attending the problem session (which will also be available through Zoom as a recording after the session). We will work through the problem during class and focus on making sure there is a firm understanding of the problem's solution. I may experiment with different deliveries for these problem sessions (i.e., use breakout rooms to let you brainstorm ideas). All problem sessions will be recorded and available through Canvas.

Total "Invested Time": It is important to point out that between viewing the lectures and attending/viewing the problem sessions that I recognize that you are investing 4.5 hours of time (roughly) into a 3-credit course. In some ways, I would argue that the problem sessions serve the purpose of reinforcing the material, like graded problems sets do. Note that the amount of time I

expect you to put into the problem sets for the course has been scaled down to reflect this. Also, there are no in-class exams, so the 'prep' time for exams is also removed from the overall effort of the course. During the first few weeks of class, I will request formal feedback as to if you find the load appropriate.

Course Materials

Philosophy: I am a firm believer that there should be a push towards open access mechanisms for course material outside of lectures. Therefore, I do not require a course textbook and only have a recommendation when it comes to a textbook. As an open access alternative, myself and a colleague have created video tutorials for use in students' first course in optimization and/or Operations Research. After several years offering these videos tutorials, I believe that students in my course can be successful using 2 of the following 3 options: lectures, video tutorials, and/or recommend course textbook.

Recommended **Additional Course Materials:** Sarah Nurre and myself have created a series of video modules and examples that are freely available for you to view to help reinforce concepts presented in this class. These videos should help to serve as a stepping stone between class examples and homework problems. For example, you could try to solve the problem covered in the video prior to viewing it to help reinforce the material. In my opinion, these videos could replace the use of the textbook and, therefore, the textbook is recommended but not required. These videos are available at:
https://sites.google.com/view/tcshark/home/education/video-tutorials-for-an-or-course

Recommended **Course Textbook:** *Introduction to Operations Research* by Hillier and Lieberman – any edition (11^{th}, 10^{th}, 9^{th}, 8^{th}).

Grading

Grading Criteria: Your final grade will be calculated according to the following areas: (1) "normal" problem sets are worth 30% of your grade, (2) "exam" problem sets are worth 40% of your grade, and (3) the modeling project is worth 30% of your grade.

Grading Policies: There are several grading policies in place for the course.

- **Grade Appeals**: It is possible for you to appeal your grade on a certain assignment. All appeals should be done within one week of when the assignment is handed back in class and must be done, in general, in a written appeal. The main exception is for minor mistakes in grading.
- **Grade Resurrection**: There will be no way to improve your grade on problem sets. The project is not due until the end of the semester; however, I will provide an opportunity for feedback (for example, what you should do to improve your potential grade) at one point in the semester.
- **Late Policies**: If you are late in turning in the homework or the project, you will receive a grade of (Original Grade) - .2*(Original Grade)*(Number of Days Late).

Grading Scheme: Although I may implement a curve up, the following are a list of the tentative cutoffs for different letter grades: A (93-100), A- (90-93), B+ (88-90), B (84-88), B- (80-84), C+ (78-80), C (74-78), C- (70-74), D (60-70), F (0-60). These grades represent lower bounds on a specific numeric grade.

"Normal" Problem Sets: There will be three normal problem sets due throughout the semester. Roughly, there will be one normal problem set for each section of the course. You *are allowed to discuss approaches to solve each problem with your classmates*; however, the final product should be representative of your own work. In other words, you may ask a classmate for clarification of the type of method that could be used and how it should be applied but you should hand in your work of applying the method to solve the problem. Please note that you can often due a subset of problems in these problem sets well before the due date. I would suggest trying to make sure you have completed the problems associated with a lecture shortly after it occurred. In order to facilitate your planning, I will provide the (approximate) date where we will cover enough material for you to complete each individual problem.

"Exam" Problem Sets: There will be two exam-like problem sets – one for the linear programming section and one for the integer programming section of the course. The key difference between these exam problem sets and the normal problem sets is that they *must be completed entirely by yourself and you cannot discuss anything about them with your classmates*. These assignments take the place of exams which is why they must be completed on your own.

Problem Set Submission: I will be using the submission system Gradescope for grading the problem sets. This system will have you upload pieces of your problem set and then 'assign' them to a particular problem. If you are hand-writing solutions to the problem set, I would recommend you taking a picture of them and then converting that picture to a pdf and then uploading them to Gradescope. Gradescope allows me to more easily standardize grading, grade quicker, and process re-grade requests quickly. I have set up a class through Gradescope and linked it to the course through Canvas. I have yet to determine if that means you all are automatically added to the course but in case you aren't, you can enter the code MP2K6P to join the class on Gradescope. Note that you may need to create a Gradescope profile.

Modeling Project: There will be a `consulting' project or, to be precise, a long-term homework assignment that will utilize concepts from throughout the different sections of the course. The description of this project will be provided the first week and will be due during final exam week (in lieu of a final exam) The purpose of the project is for you to select which modeling approaches and OR methods to utilize to provide key insights into decisions that will be made for a potential company. I will provide you an *optional* opportunity to submit a draft project in order for me to assess your work to date. The feedback on these partial projects will be rigorous so that you may address my concerns in preparing the final project.

Policies and Procedures

Attendance Policies: Attendance is not mandatory, although it is encouraged that you attend all problem sessions. Although class participation is not listed as part of your evaluation, it will be

helpful in you learning the material and may positively affect your grade. You are responsible for viewing all "lectures" and using the problem sessions to help you master the material.

Academic Integrity: "As members of the Clemson University community, we have inherited Thomas Green Clemson's vision of this institution as a "high seminary of learning." Fundamental to this vision is a mutual commitment to truthfulness, honor, and responsibility, without which we cannot earn the trust and respect of others. Furthermore, we recognize that academic dishonesty detracts from the value of a Clemson degree. Therefore, we shall not tolerate lying, cheating, or stealing in any form."

The university's undergraduate academic integrity policy can be found at the following URL: https://www.clemson.edu/academics/integrity/
The university's graduate academic integrity policy can be found at the following URL: https://www.clemson.edu/graduate/students/policies-procedures/index.html

Students may not submit any work that has been turned in for credit for a previous course. We will assume that all students are familiar with this policy. It is expected that all work for this course will be generated in response to the assignments given in this course.

Students suspected of academic dishonesty will be brought to the Academic Integrity Board. I have designed the course assessments in a way that has demonstrated my trust in my students and I will pursue appropriate punishments for those that violate this trust.

Accessibility: Clemson University values the diversity of our student body as a strength and a critical component of our dynamic community. Students with disabilities or with temporary injuries/conditions may require accommodations due to barriers in the structure of facilities, in the learning environment, with technology used for curricular purposes, or other campus resources.

Students who experience a barrier to full access should let the professor know and make an appointment to meet with a staff member in Student Accessibility Services as soon as possible. You can make an appointment by calling 864-656-6848, by visiting Suite 239, or emailing studentaccess@lists.clemson.edu, in the Academic Success Center building. Appointments are strongly encouraged – drop-ins will be seen if possible, but there could be a significant wait due to scheduled appointments.

Students who receive Academic Access Letters are strongly encouraged to request, obtain and present these to their professors as early in the semester as possible so that accommodations can be made in a timely manner. It is the student's responsibility to follow this process each semester. Note that "Students registered with Student Accessibility Services can request their Faculty Notification Letters using the Request Faculty Notification Letters link (https://rainier.accessiblelearning.com/Clemson). Students will log in with their Clemson credentials and can request the letters that they would like to be sent to their professors electronically. If students have any additional questions, please contact the SAS office". You can access further information at the Student Accessibility Services website: https://www.clemson.edu/academics/studentaccess/

Clemson University Title IX (Sexual Harassment) Statement: Clemson University is committed to a policy of equal opportunity for all persons and does not discriminate on the basis of race, color, religion, sex, sexual orientation, gender, pregnancy, national origin, age, disability, veteran's status, genetic information or protected activity in employment, educational programs and activities, admissions and financial aid. This includes a prohibition against sexual harassment and sexual violence as mandated by Title IX of the Education Amendments of 1972. This policy is located at http://www.clemson.edu/campus-life/campus-services/access/title-ix/. Ms. Alesia Smith is the Clemson University Title IX Coordinator, and the Executive Director of Equity Compliance. Her office is located at 110 Holtzendorff Hall, 864.656.3181 (voice) or 864.656.0899 (TDD).

Course Schedule

The course is broken down into three major sections concerning different classes of optimization problems: (1) linear programming (LP), (2) integer programming (IP), and (3) network optimization (NO). In each section, we will learn about how to *model* with a particular class, how to *solve* problems in this class, and how to *analyze* the solutions.

Noted: Assignments will be due on the Friday of the corresponding week.

Week	Monday Class	Wednesday Class	Friday Class	Deliverables
1		8/19: Syllabus and Class Introduction	8/21: LP: Two-Variable Linear Programs	Normal PS 1 Posted
2	8/24: LP: Modeling Shift Scheduling with LPs	8/26: LP: Modeling 'Mixing' Problems with LPs	8/28: LP: Additional Modeling Considerations	
3	8/31: LP: Software Packages	9/2: LP: Introduction to the Simplex Method	9/4: LP: The Simplex Method	
4	9/7: LP: Special Considerations in the Simplex Method	9/9: LP: Duality	9/11: LP: Properties of Duality	Normal PS 1 Due
5	9/14: LP: Sensitivity Analysis	9/16: LP: Other Solution Methods	9/18: LP: Wrap-Up and Review	Exam PS 1 Posted
6	9/21: IP: Basic Models	9/23: IP: Capacity Expansion Models	9/25: IP: Assignment Models	
7	9/28: IP: Either/OR Models	9/30: No "Official" Class – Work on Exam HW 1.	10/2: IP: Discount Scheme Models	Exam PS 1 Due, Normal PS 2 Posted
8	10/5: IP: Branch and Bound	10/7: IP: Branch and Bound	10/9: IP: Software Packages	Modeling Project Posted

9	10/12: IP: "Quality" Models	10/14: IP: Breaking Symmetry	10/16: IP: Advanced Considerations	Normal PS 2 Due
10	10/19: IP: Branch and Cut	10/21: IP: Branch and Cut	10/23: IP: Wrap-Up and Review	Exam PS 2 Posted
11	10/26: NO: Preliminaries	10/28: NO: The Shortest Path Problem	10/30: NO: Shortest Path Applications	
12	11/2: No Class, Fall Break	11/4: No "Official" Class – Work on Exam HW 2.	11/6: NO: Minimum Spanning Trees	Exam PS 2 Due
13	11/9: NO: Max Flow Problem	11/11: NO: Max Flow/Min Cut Duality	11/13: NO: Max Flow Applications	Normal PS 3 Posted
14	11/16: NO: Min Cost Flow Problem	11/18: NO: Min Cost Flow Applications	11/20: Modeling Project Consults	
15	11/23: Modeling Project Consults	11/25: No Class, Thanksgiving Break	11/27: No Class, Thanksgiving Break	
16	11/30: TBD and/or Case Studies	12/2: TBD Case Studies	12/4: TBD Case Studies	Normal PS 3 Due
17	Exam Week			Modeling Project Due