MATH 4420-001/ 6420-001 – Advanced Mathematical Programming
Spring 2022 – Syllabus

T, Th, 12:30 – 1:45 p.m., Room Martin M-204

Instructor: **Dr. Margaret Wiecek**
e-mail: wmalgor@clemson.edu
Office hours: on Zoom, T, Th 11:00 a.m. – 12:00 p.m. or by appointment; use the Zoom link on Canvas
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Required Text: J. G. Ecker and M. Kupferschmid, *Introduction to Operations Research,* Wiley 1998, reprinted by Krieger 2004.

Software: The students will be expected to use software packages for solving optimization problems. The packages include

i) http://www.maximalsoftware.com/download/
ii) http://www.lindo.com/index.php/lsdownloads
iii) MATLAB available on the computers in our lab
iv) demo version of AMPL with some solvers (LPs, convex quadratic programs, smooth nonlinear programs) is available for free for download from http://ampl.com/try-ampl/download-a-demo-version/#windows
v) any other software selected by a student and approved by the instructor.

Prerequisite: Multivariable calculus (e.g., MATH 2060), linear algebra (e.g., MATH 3110), linear programming (e.g., MATH 4400/6400) or another entry-level optimization course.

MATH 4420 is a capstone course for all mathematical sciences majors with Operations Research /Management Science emphasis area.
As stated in
https://catalog.clemson.edu/preview_program.php?catoid=33&poid=8540
"a capstone course shall provide an opportunity to pursue research, independent study, or an approved internship under the direction of a faculty member, or the opportunity to study mathematical models in some area of the mathematical sciences. **The capstone experience requires a written report (thesis, computer code, project description, intern experience, etc.) and an oral or poster presentation by each student."**

Goal: Introduce students to mathematical programming models and methods used for solving decision-making problems in business and industry.

Description: Mathematical programming is part of a broader interdisciplinary field referred to as Operations Research (OR), which is the application of analytical methods to decision problems in engineering and management. OR has two fundamental parts: (1) creating mathematical models of decision problems and (2) developing methods to solve

those models. One mathematical subject encompassed by OR is optimization. A first course in optimization such as MATH 4400/6400 covers models making use of linear functions and continuous variables, which are known as linear programming and network flow problems. In MATH 4420/6420, we focus on more advanced optimization models making use of integer variables, nonlinear functions (e.g., quadratic, convex) making up the objective or constraint functions, and multiple objective functions.

Topical Outline: The course covers three types of optimization problems. Each part includes modeling, theory, methodology, and applications.

Class overview: integer, convex, biobjective models.

Integer optimization
- Review of linear programming.
- Application-based modeling with integer and combinatorial optimization problems.
- The branch-and-bound algorithm.

Convex optimization
- Review of multivariable calculus.
- Application-based modeling with nonlinear optimization problems.
- Convexity of sets and functions.
- Unconstrained optimization.
  - Optimality conditions
  - Algorithms for optimization on a line.
  - Algorithms for optimization in higher dimensions.
- Constrained optimization.
  - Optimality conditions.
  - Algorithms.

Biobjective optimization
- Conceptual modeling with biobjective optimization problems.
- Efficient solution and Pareto outcomes.
- Scalarizations.
- Conditions for efficiency.
- Problems with continuous and integer variables.
- Applications.

Student learning objectives: The successful student will be able to
- develop mathematical optimization models for various decision-making problems
- identify properties of the solution sets of optimization problems
- solve small-size optimization problems analytically
- solve optimization problems using software
- analyze mathematical optimization models to get additional insight into the real-life problem

Learning Environment:

- **University policy on testing and wearing masks due to COVID19:** A universal mask requirement and weekly testing requirement applies to all students taking this course.

- Class modality due to COVID19: Every effort will be made to offer the entire course in person.

(i) If the instructor is assigned to quarantine or isolation, the course modality will transition to online or the course will be taught by another instructor for some number of classes. The students will be notified by email if the course modality changes.

(ii) If a student is assigned to quarantine or isolation, they are to notify the instructor through the Notification of Absence (NOA) tool. They might wish to have homework assignments due dates changed because of their medical condition.

(iii) If a significant number of students become sick, or assign to quarantine or isolation, the course modality may transition to online for some number of classes. The students will be notified by email if the course modality changes.

- Transmitting and recording the class on Zoom: During in-person classes the instructor will use the chalk board and will rely on students' help to transmit and record the class on Zoom. If online students are present, an online student will be asked to control the camera from their computer to make the chalk-board visible in the recording. Otherwise, a volunteer student in the classroom will be needed to help and control the camera using the camera remote controller. Recorded classes will be posted on Canvas. The instruction for online students on how to control the camera are as follows:
Controlling the camera by online students: While on Zoom, a student
- clicks on the thumbnail view of the instructor
- clicks on three dots
- requests camera control

The instructor gets a pop-out to approve the request. The buttons to control the camera show up on the student's screen.

- **Resources posted on Canvas:** recordings of the lectures, lecture notes, additional notes, slides, links to online resources.

- **Virtual office hours on Zoom**: use the Zoom link on Canvas

- Websites: Use the website https://clemson.instructure.com/ and follow links to our section of MATH 4400 in Canvas. This course section website will house all course materials. You are responsible for checking this website and your university email account (userid@clemson.edu OR userid@g.clemson.edu) ***after/before each class*** for announcements and class materials.

Electronic equipment:

Use of cell phones is strongly discouraged during class.

- Required: Computer equipped with camera and microphone, and scanner to scan and submit completed work to be graded.
- Recommended: A (simple) calculator. Students may use their preferred calculators and are responsible for their use. Calculator related questions will not be answered in class.

Assessment Activities:

- **Homework assignments**: Homework will be assigned and collected on a regular basis. Working on the assignments constitutes the student's primary involvement in the course material, and it is essential that this work is regularly completed. The students are required to scan their work and submit it through Canvas on time. The solutions to some assigned problems may be posted after the assignments have been collected.

Late work will be accepted but the grade will be lowered by 10% if the work is turned in past the due date. However, homework assignment (or its part) submitted after the solutions have been posted will receive a zero score.

- Project: Working on the project will involve the following tasks throughout the semester:

1. JANUARY: Conduct a literature search. Look for a published research article of your interest in the area of integer, convex, or biobjective programming. Review several articles in order to grasp their general topic. A suitable paper should be neither trivial nor very challenging. It should address a decision making situation of your interest, and contain data and computational results that you will be able to reproduce. Use search engines such as Google Scholar or Web of Science through Clemson University library. Think of keywords that will lead you to papers with interesting applications.

Feel free to consult the instructor to discuss the suitability of the paper. Note that a successful search may take several exchanges of emails with the instructor who may take up to 24 hours to reply to each inquiry.

The students in MATH 6420 are encouraged to choose an article related to their program of study or propose a project based on their own research.

2. BY FEBRUARY 1: Obtain instructor's approval on a paper and schedule a class presentation. You may have to contact the instructor several times in January to find a suitable paper and get the approval on time.

Send email to the instructor to
(i) submit the selected paper for approval
and
(ii) schedule a class presentation during our class time in the period March 1-17. Three presentations per class will be possible.
<u>The final grade for the oral presentation will be lowered by 10% for late submission.</u>

3. FEBRUARY: Study the paper and prepare a Power Point presentation on the paper's content. Understanding all details may very often require using some other bibliographical sources (other articles or books cited in the paper, textbooks, etc.). The presentation shall cover the following:

a) goal of the work presented in the paper
b) real life situation addressed in the paper
c) mathematical model(s) presented
d) solution technique(s) introduced
e) results included
f) your opinion about applicability of the model(s) to the situation under consideration

4. MARCH: Give oral presentation. On your scheduled day **in March**, using your Power Point slides give a 15-20-minute class presentation that will be followed by a class discussion during which the other students will be expected to ask questions to the presenter. The presentation and discussion shall not exceed 25 minutes.

If the student is in quarantine or isolation due to COVID19 on the day of presentation, they are to notify the instructor through the Notification of Absence (NOA) tool. They may choose to present via Zoom or reschedule the presentation because of their medical condition.

If a student misses the presentation for a reason that would qualify as an excused absence, notifies the instructor through the NOA tool, and provides proper documentation, the student presentation will be rescheduled. The following events qualify for an excused absence: illness, quarantine, isolation, family problems, university function, military duty, court attendance.

5. APRIL: Perform computational work and write a final report.
Perform computational work to reproduce the results in the paper and write the final report. Note that obtaining the results may require coding or learning how to use a new software.
The report shall be typed and include the following sections:

a) - f) given in point 3. above
f) your computational results
g) comparison of your results to those in the paper
h) description of the software you used
i) your opinion and justification what other mathematical models studied in this class would be suitable to model the problem in your paper and why.

6. BY MAY 2, 5:30 pm: Submit the final report by email to the instructor wmalgor@clemson.edu
The final grade for the written report will be lowered by 10% for late submission.

Grading:

-Weights:	homework assignments	30%
	class participation during presentations in March	10%
	class presentation	30%
	written report	30%

The scores for class presentation, class participation, and final report are based on an increment of 5: {. . . , 60, 65,70, 75, 80, 85, 90, 95, 100}

The score on the class presentation is based on:
- difficulty level of the selected paper (40%)
- mathematical correctness (20%)
- completeness (20%)
- clarity of speaking (including answering questions) (20%)

The score on the final report is based on:
- difficulty level and quality of the computational work (40%)
- mathematical correctness (20%)
- completeness (20%)
- clarity of writing (20%)

- Scale: A (90-100); B (80-89); C (70-79); D (60-69); F (59 and below)

Final grades: In general, the grading scale will be followed. The students will not be given any additional opportunities to improve their anticipated final grade at the end of the semester.

Class cancellation: A class is canceled 15 minutes after the instructor fails to arrive.

Attendance: Should the student decide that they do not need to come to class or attend online with no valid excuse, they shall get the information from a classmate. If the student does have a valid excuse, the instructor will be glad to help.

University Policies

Student Accessibility Services: Clemson University values the diversity of our student body as a strength and a critical component of our dynamic community. Students with disabilities or temporary injuries/conditions may require accommodations due to barriers in the structure of facilities, course design, technology used for curricular purposes, or other campus resources. Students who experience a barrier to full access to this class should let the instructor 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 emailing studentaccess@lists.clemson.edu, or by visiting Suite 239 in the Academic Success Center building. Appointments are strongly encouraged –

drop-ins will be seen, if at all possible, but there could be a significant wait due to scheduled appointments. Students who have accommodations are strongly encouraged to request, obtain and send these to their instructors through the AIM portal 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. You can access further information at the Student Accessibility website. Other information is at the university's Accessibility Portal.

The Clemson University Title IX 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 Title IX policy is located on the Campus Life website. Ms. Alesia Smith is the Clemson University Title IX Coordinator, and the Executive Director of Equity Compliance. Her office is located at 223 Brackett Hall, 864.656.0620. Remember, email is not a fully secured method of communication and should not be used to discuss Title IX issues.

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. All infractions of academic dishonesty by undergraduates must be reported to Undergraduate Studies for resolution through that office. In cases of plagiarism instructors may use the Plagiarism Resolution Form. See the Undergraduate Academic Integrity Policy website for additional information and the current catalogue for the policy.

Emergency Preparedness: Emergency procedures have been posted in all buildings and on all elevators. Students should be reminded to review these procedures for their own safety. All students and employees should be familiar with guidelines from the Clemson Police Department. Visit here for information about safety.

Clemson University is committed to providing a safe campus environment for students, faculty, staff, and visitors. As members of the community, we encourage you to take the following actions to be better prepared in case of an emergency:

1. Ensure you are signed up for emergency alerts
2. Download the Rave Guardian app to your phone (https://www.clemson.edu/cusafety/cupd/rave-guardian/)
3. Learn what you can do to prepare yourself in the event of an active threat (http://www.clemson.edu/cusafety/EmergencyManagement/)

Copyright: All materials found in this course are strictly for the use of students enrolled in this course and for purposes associated with this course; they may not be retained or further disseminated. Clemson students, faculty, and staff are expected to comply fully with institutional copyright policy as well as all other copyright laws.

Privacy Policy: This course is designed with your privacy in mind. If, however, you feel that an assignment or technology tool undermines your right to privacy, please contact the instructors immediately. We will work together to determine an alternative assignment that will help you achieve the course learning outcomes.

Online Conduct: Appropriate online academic conduct means maintaining a safe learning environment based on mutual respect and civility. All participants in Clemson courses are expected to behave professionally by adhering to these standards of conduct:

- Never transmit or promote content known to be illegal.
- Respect other people's privacy as well as your own.
- Forgive other people's mistakes.
- Never use harassing, threatening, embarrassing, or abusive language or actions.

Online communication that fails to meet these standards of conduct will be removed from the course. Repeated misconduct may result in being blocked from online discussions, receiving a grade penalty, or being dismissed from the course. Such misconduct in the online environment may also be reported to officials for appropriate action in accordance with University policy. If you ever encounter inappropriate content in our course, please contact the instructors with your concerns.

Registrar: The Registrar's office provides information about important deadlines, degree and program requirements, and other key information, including use of iROAR to add, drop, or withdraw from courses. In particular, note the following important dates:
- January 19: last day to register or add a class or declare audit;
- January 26: last day to drop a class or withdraw from the University without a W grade;
- March 18: last day to drop a class or withdraw from the University without final grades.