



ESI6420 - Fundamentals of Mathematical Programming - Fall 2022
Herbert Wertheim College of Engineering
Department of Industrial & Systems Engineering (ISE)
Instructor: Jorge A. Sefair (jorge.sefair@ise.ufl.edu)
T: Period 7 (1:55 PM - 2:45 PM) FLI 0117
R: Periods 7-8 (1:55 PM - 3:50 PM) WEIM 1076

Motivation: “*Optimization is everywhere. It is human nature to seek the best option among all that are available. Nature, too, seems to be guided by optimization – many laws of nature have a variational character*” (Güler, 2010).

Course overview: First course of the PhD-level deterministic course series. The course will introduce the fundamentals of optimization, geared towards doctoral and advanced graduate students. The emphasis is on the theoretical foundations of optimization, classical mathematical programming, and main optimization paradigms. This course also serves as a primer for students interested in developing their mathematical proofing skills. Although some applications and algorithms are discussed, the emphasis is theoretical.

Catalog description: Introducing mathematical programming with an emphasis on classical optimization concepts, models and solution techniques. Focus on convex analysis (convex sets, separation theorems, convex functions), optimality conditions (Fritz-John Karush-Kuhn-Tucker), Lagrangian duality and iterative solution methods gradient, conjugate gradients barrier methods.

Prerequisites: Proficiency in linear algebra, calculus, and basic analysis. Prior knowledge of how to formulate linear programs is also required. Moreover, students should be familiar with a programming language (C++, Matlab, Java, Python) or should have the motivation to learn.

Learning Outcomes: At the end of the course, students will be able to (1) mathematically prove fundamental results in optimization, (2) recognize and formulate nonlinear optimization problems, (3) identify when a problem is convex, (4) understand classical results characterizing optimal solutions to these problems, (5) use these classical results in application problems and design of algorithms, and (6) use commercial software (e.g., AMPL) to implement optimization models.

Course Outline (tentative):

Chapter	Topics
Motivation	Introduction to optimization, modeling, selected optimization problems, AMPL.
Convex sets	Basic definitions, convex hull, extreme points and directions, separation theorems, Farkas’ lemma and related theorems, special convex sets: polyhedral sets, representation theorem, linear programming and duality.
Convex functions	Basic definitions, subgradients, Hessian matrices, testing positive definiteness and positive semidefiniteness, local and global minima of functions, families of convex programs, convex relaxations.
Optimality conditions	Optimality conditions in convex programs, first and second order conditions for unconstrained and constrained problems, Fritz-John conditions, Karush-Kuhn-Tucker (KKT) conditions - first order necessary and first order sufficient conditions, KKT conditions - second order necessary and second order sufficient conditions, constraint qualifications.
Duality	Lagrangian duality, weak duality, duality gap and KKT conditions, duality gap and saddle points of the Lagrangian function, special cases: linear and quadratic programming.

Instructor:

- Contact: jorge.sefair@ise.ufl.edu
- Office: 401A Weil Hall
- Office hours: T 3:00 - 4:30 PM (in person or Zoom, by appointment)

Textbook:

- Nonlinear Programming: Theory and Algorithms, 3rd Edition. 2006. M.S. Bazaraa, H.D. Sherali, and C.M. Shetty. Wiley.

Additional reading

- Convex Optimization. S. Boyd and L. Vandenberghe. 2004. Cambridge University Press.
- Nonlinear Optimization. A. Ruszczyński. 2006. Princeton University Press.
- Foundations of Optimization. O. Güler. 2010, Graduate Texts in Mathematics, Vol. 258. Springer.
- Nonlinear Programming, 2nd Edition. 2004. D. P. Bertsekas. Athena Scientific.
- AMPL: A Modeling Language For Mathematical Programming, 2nd ed. 2002. R. Fourer, D.M. Gay, and B.W. Kernighan. Cengage Learning. URL: <http://ampl.com/resources/the-ampl-book/>

Optimization Software:

- AMPL. Unrestricted version available in Canvas (Linux, macOS 64, Windows 32 and 64). Linear and nonlinear state-of-the-art solvers (Baron, Knitro, Cplex, Gurobi).

Grade Distribution: Homework (×3): 25% – Exam 1: 25% (September 27) – Exam 2: 25% (November 8) – Final Exam: 25% (**December 15 10:00 AM - 12:00 PM**)

Exams rules: Exams are comprehensive and closed book, closed notes, no cheat sheets, no calculator. There will be no make up exams. In the event of a university-approved absence on an exam day, the final exam grade will be used as a substitute for the missed exam. Notify the instructor ahead of time, whenever possible.

Letter Grade Distribution:

Final average	Grade	Final average	Grade	Final average	Grade	Final average	Grade
> 100.00	A+	[85, 90)	B+	[70, 75)	C+	< 55	E
[95, 100)	A	[80, 85)	B	[65, 70)	C		
[90, 95)	A-	[75, 80)	B-	[55, 65)	D		

More information on UF grading policy may be found at <https://gradcatalog.ufl.edu/graduate/regulations/> and <https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx>.

Course Policies:

- **Communications:** All the course-related materials will be available in Canvas.
- **Class Attendance and Participation:** Student attendance is encouraged and active participation is expected. If you anticipate not being able to attend any face to face classes due to travel restrictions or personal health concerns, contact me at the beginning of the semester or as soon as your situation changes. If you chose to attend the class in person **you must adhere to the university policies on distancing and mask use**. Excused absences must be consistent with university policies in the Graduate Catalog¹ and require appropriate documentation. Please read the updated university attendance policies.²
- **Accommodations:** Accommodations will be made in situations related to religious observances/practices, officially university-sanctioned activities, and missed class due to military line-of-duty activities. Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the disability Resource Center by visiting <https://disability.ufl.edu/students/get-started/>. It is important for students to share their accommodation letter with their instructor and discuss their access needs, as early as possible in the semester.
- **In-Class recording:** Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor. A “class lecture”

¹<https://gradcatalog.ufl.edu/graduate/regulations/>

²<https://catalog.ufl.edu/ugrad/current/regulations/info/attendance.aspx>

is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session. Publication without permission of the instructor is prohibited. To “publish” means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.

- **Commitment to a Safe and Inclusive Learning Environment:** The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture. If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

- Your academic advisor or Graduate Program Coordinator
- Jennifer Nappo, Director of Human Resources, 352-392-0904, jpennacc@ufl.edu
- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, taylor@eng.ufl.edu
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, ishida@eng.ufl.edu

- **Course evaluation:** Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at gatorevals.aa.ufl.edu/students/. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via ufl.bluera.com/ufl/. Summaries of course evaluation results are available to students at gatorevals.aa.ufl.edu/public-results/.

- **University honesty policy:** UF students are bound by The Honor Pledge which states, “We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code”. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: “On my honor, I have neither given nor received unauthorized aid in doing this assignment”. The Honor Code³ specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class. This course will follow the ethical standards of the University of Florida at large. Plagiarism, cheating, and dishonesty will not be tolerated.

- **Software use:** All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or

³<https://www.dso.ufl.edu/sccr/process/student-conduct-honor-code/>

criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

- **Student privacy:** There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: <http://registrar.ufl.edu/catalog0910/policies/regulationferpa.html>.

- **Campus resources:**

Health and Wellness

- U Matter, We Care: Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact umatter@ufl.edu so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.
- Counseling and Wellness Center: <http://www.counseling.ufl.edu/cwc>, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.
- Sexual Discrimination, Harassment, Assault, or Violence. If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the Office of Title IX Compliance⁴, located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, title-ix@ufl.edu
- Sexual Assault Recovery Services (SARS) Student Health Care Center, 392-1161.
- University Police Department at 392-1111 (or 9-1-1 for emergencies), or <http://www.police.ufl.edu/>.

Academic Resources

- E-learning technical support, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu. <https://lss.at.ufl.edu/help.shtml>.
- Career Resource Center, Reitz Union, 392-1601. Career assistance and counseling. <https://www.crc.ufl.edu/>.
- Library Support, <http://cms.uflib.ufl.edu/> ask. Various ways to receive assistance with respect to using the libraries or finding resources.
- Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring. <https://teachingcenter.ufl.edu/>.
- Writing Studio, 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers. <https://writing.ufl.edu/writing-studio/>.
- Student Complaints Campus: https://www.dso.ufl.edu/documents/UF_Complaints_policy.pdf.
- On-Line Students Complaints: <http://www.distance.ufl.edu/student-complaint-process>

⁴<https://titleix.ufl.edu/>