

COURSE SYLLABUS

ESI 6448: Discrete Optimization Theory
Spring 2025*Instructed by Aleksandr M. Kazachkov***Overview**

<i>Credits</i>	3 (no pass/fail allowed)
<i>Meetings</i>	Tues., 1:55–2:45pm (pd. 7), Weil 401E Thurs., 12:50–2:45pm (pds. 6–7), Weil 401E
<i>Virtual*</i>	https://ufl.zoom.us/j/91979933355 , password: 32611
<i>Website</i>	Canvas through elearning.ufl.edu

Instructor:	Aleksandr M. Kazachkov (he/him/his)
<i>Email</i>	akazachkov@ufl.edu (see Communication Guidelines below)
<i>Office</i>	Weil 401B or https://ufl.zoom.us/j/91979933355 , password: 32611
<i>Office hours</i>	TBD based on class poll
<i>Phone</i>	+1.352.273.4902

Syllabus Contents

1 Course Description and Objectives	2
2 Guidelines on Communication and Class Meetings	2
3 Tentative Course Schedule	3
4 Class Materials	4
5 Grading Policy, Assignments, Exams, and Effort	4
5.1 Evaluation of Grades	4
5.2 Attendance & Participation	5
5.3 Homework	5
5.4 Exams	6
5.5 Project	6
5.6 Regrade Policy	6
6 Honor Code	6
7 Course Evaluation	7
8 Course Recording	7
9 Accommodations	8
10 Student Privacy	8
11 Commitment to a Safe and Inclusive Learning Environment	8
12 Campus Resources	9
12.1 Health and Wellness	9
12.2 Academic Resources	9

*The mode of instruction for this course is *primarily in person* and **attendance is mandatory**. Please use the Zoom link only for office hours or if you are told that a lecture can be attended virtually.

1 Course Description and Objectives

Catalog Description of ESI 6448

3 Credits (Letter Grade)

Modeling with integer variables; enumeration and cutting plane methods; decomposition algorithms; branch and bound methods; computational complexity and software issues; special combinatorial optimization problems; parallel algorithms for integer programming.

Prerequisite: Linear programming and nonlinear optimization or equivalent.

Instructor’s Description of the Class *This class is not likely to be taught every year.*

Integer programming is a powerful and flexible modeling technique, widely used in industrial and academic settings, such as allocating organs to patients while ensuring high-quality transplants, or efficiently dispatching and routing vehicles in ridesharing applications and during emergencies. These contexts require *discrete variables* that can capture “either-or” requirements, “on-off” decisions, or selecting from a countable set of options. In general, it is theoretically difficult to solve problems with integrality restrictions; nevertheless, in practice, large-scale instances are now regularly solved, due to theoretical, algorithmic, and engineering advances that are the subject of the course. We cover the fundamentals of **integer programming theory**, emphasizing the core components of modeling and solving an integer programming problem through *proof-based* theoretical development. Later in the semester, if time permits, recent and ongoing research topics are covered.

Prerequisites Students should have *mathematical maturity*, be prepared to **write proofs** (and **write well**), and have familiarity with **linear optimization fundamentals**.

Learning Outcomes By the end of this course, you will be expected to:

- Define integer variables to model a variety of discrete decisions and constraints
- Derive inequalities to tighten a linear programming relaxation of a given integer program, including proving a particular inequality is valid, analyzing whether a valid inequality defines a facet of the integer hull, and computing common cuts
- Explain the key steps and engineering decisions in a branch-and-bound algorithm and the interplay of enumeration with cutting plane methods
- Decompose an integer programming problem based on row / column generation techniques

The course objectives will be pursued through exercises in various forms to help you understand and communicate these concepts, particularly via assignments asking you to prove integer programming properties.

Disclaimer The content of this syllabus, particularly the course schedule, is subject to change throughout the semester. The latest version will be posted on Canvas.

2 Guidelines on Communication and Class Meetings

Communication Guidelines

Canvas Please use Canvas Discussions to ask all nonconfidential course questions.

Email Emails regarding this course should have “[ESI 6448]” in the beginning of the Subject line, so your email can be answered more quickly.

3 Tentative Course Schedule

Wk	Day	Topics	Reading	Assignments
1	Jan 14	Course introduction	W 1.1	HW 0 out (ungraded)
	Jan 16	Terminology and basic concepts	CCZ 1.1, 1.4; W 1.2–1.3	HW 0 due, HW 1 out
2	Jan 21	Complexity	CCZ 1.3; W 1.4, 6.1–6.4	
	Jan 23	Linear algebra and proofs review		
3	Jan 28	Formulations and models	CCZ 2; W 1.5–1.7	HW 1 due
	Jan 30	Alternative formulations	CCZ 2; W 1.5–1.7	HW 2 out
4	Feb 04	Fourier-Motzkin elimination, Farkas's lemma	CCZ 3.1–3.2; W 2.5–2.6	
	Feb 06	Duality	CCZ 3.3; W 2.5–2.6	
5	Feb 11	Early feedback and wiggle room day		HW 2 due
	Feb 13	Polyhedra and Minkowski-Weyl Theorems	CCZ 3.4–3.5	HW 3 out
6	Feb 18	Recession cone, dimension of polyhedra	CCZ 3.6–3.7; W 9.1–9.2	
	Feb 20	Faces, valid inequalities, and facets	CCZ 3.8–3.9	
7	Feb 25	More facets; vertices, edges, and extreme rays	CCZ 3.9–3.11	HW 3 due
	Feb 27	Chvátal, Gomory, mixed-integer rounding	CCZ 1.2.2, 5.1–5.3; W 8.6–8.7	HW 4 out
8	Mar 04	Intersection cuts: proof of validity	CCZ 6.1–6.2	
	Mar 06	Intersection cuts: Gomory mixed-integer cuts	CCZ 6.1–6.2	HW 4 due
9	Mar 11	Maximal lattice-free convex sets	CCZ 6.2	HW 5 out
	Mar 13	In-class exam 1		
10	Mar 18	Spring break		
11	Mar 25	Enumeration, branch-and-bound	CCZ 1.2.1; W 2.1–2.2, 7.1–7.4	HW 5 due
	Mar 27	Union of polyhedra and disjunctions	CCZ 4.9	HW 6 out
12	Apr 01	Projection and extended formulations	CCZ 3.15	
	Apr 03	Lift-and-project cuts, split cuts	CCZ 5.1, 5.4; W 8.8	HW 6 due
13	Apr 08	Split rank, split closure	CCZ 5.1	HW 7 out
	Apr 10	Lagrangian relaxation	CCZ 8.1; W 2.4, 10	
14	Apr 15	Decomposition techniques	CCZ 8.2–8.3; W 11.1–11.3, 12	HW 7 due, HW 8 out
	Apr 17	Paper presentations		
15	Apr 22	Paper presentations		HW 8 due
	Apr 24	Reading days		
16	Apr 28	Exam week		Take-home exam 2

4 Class Materials

There is no required textbook or materials & supplies fee. I suggest the following references:

- Michele Conforti, Gérard Cornuéjols, Giacomo Zambelli, *Integer Programming*, Springer, 2014. ISBN 978-3-319-11008-0 (free online access).
- Michael Jünger, Thomas M. Liebling, Denis Naddef, George L. Nemhauser, William R. Pulleyblank, Gerhard Reinelt, Giovanni Rinaldi, Laurence A. Wolsey, *50 Years of Integer Programming 1958–2008*, Springer, 2010. ISBN 978-3-540-68279-0 (free online access).
- Laurence A. Wolsey, *Integer Programming*, 2nd Ed., Wiley, 2020. ISBN 9781119606536.

Other references that may be useful:

- Laurence A. Wolsey, George L. Nemhauser, *Integer and Combinatorial Optimization*, 2nd Ed., Wiley, 1999. ISBN 978-0-471-35943-2. Free online access: <https://ebookcentral.proquest.com/lib/ufl/detail.action?docID=1776322>.
- Jon Lee, *A First Course in Linear Optimization*, 4th Edition (Version 4.08), Reex Press, 2013–25. https://github.com/jon77lee/JLee_LinearOptimizationBook
- Arkadi Nemirovski, *ISyE 6661 Lecture Notes: Introduction to Linear Optimization*, 2024. <https://www2.isye.gatech.edu/~nemirovs/OPTILN2024FallNoSol.pdf>
- Alexander Schrijver, *Theory of Linear and Integer Programming*, Wiley, 1997. ISBN 978-0-471-98232-6.
- Dimitris Bertsimas and John N. Tsitsiklis, *Introduction to Linear Optimization*, Athena Scientific, 1997. ISBN 1-886529-19-1.

You are expected to take your own class notes, but any slides that are prepared for the course will be made available to you. These are not intended to replace the actual lecture, but rather to serve as an outline. *Any material I distribute to the class should be kept strictly within this class; without my express permission, you cannot share course content (aside from this syllabus) to anyone not enrolled in the class.*

Instructional materials for this course consist of only those materials specifically reviewed, selected, and assigned by the instructor. The instructor is only responsible for these instructional materials.

Software Use All faculty, staff, and students of the University of Florida 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 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.**

5 Grading Policy, Assignments, Exams, and Effort

5.1 Evaluation of Grades

Your course grade will be based on the following components (your unweighted score, prior to any curving, will be the maximum of the two criteria):

Component	Criterion 1 (%)	Criterion 2 (%)
Participation	5	5
Homework	45	35
Paper presentation	15	15
Exam 1	15	20
Exam 2	20	25

You should expect to spend **~6 hours** on this class per week, on average, outside of lectures.

The (tentative) grading scale is: A = $[93.\bar{3}, 100]$, A⁻ = $[90, 93.\bar{3})$, B⁺ = $[86.\bar{6}, 90)$, B = $[83.\bar{3}, 86.\bar{6})$, B⁻ = $[80, 83.\bar{3})$, C⁺ = $[76.\bar{6}, 80)$, C = $[73.\bar{3}, 76.\bar{6})$, C⁻ = $[70, 73.\bar{3})$, D⁺ = $[66.\bar{6}, 70)$, D = $[63.\bar{3}, 66.\bar{6})$, D⁻ = $[60, 63.\bar{3})$, E = $[0, 60)$. Some assignments or exams may be curved if the average is too low. See also the Graduate Academic Regulations on Grading at catalog.ufl.edu/graduate/regulations.

5.2 Attendance & Participation

Attendance is mandatory, but will not be directly recorded. Participation is based on in-class activities and virtual discussions via Canvas; active involvement in both is highly encouraged. In-class activities may include graded or ungraded quizzes or group work to reinforce class concepts and gain hands-on experience. You will be able to use your notes.

Requirements for class attendance and make-up exams, assignments, and other work in this course are consistent with university policies. Click here to read the university attendance policies: catalog.ufl.edu/UGRD/academic-regulations/attendance-policies.

5.3 Homework

Homework will consist of individual assignments to develop your skills in modeling real-world problems, employing integer programming concepts, and proving/practicing key discrete optimization properties. For each homework assignment, you will submit: (1) one write up with all work shown (not just an answer), with your name clearly written; (2) a *separate* page with attributions (sources) consulted for every question.

Collaboration Policy You *are* allowed to discuss problems with other students in the class, such as via Canvas, but you *cannot* share complete answers with each other before everyone involved in the discussion has submitted their work. However, I strongly encourage you to first **sincerely attempt each problem on your own**, and to *learn* from any external references you consult. If you have attempted a problem on your own but could not find a solution, your next step should be to talk to your classmates or me. You may also refer to online resources, but do not abuse this policy: if you find a solution or partial solution to a problem, please leave it aside and only refer to it as a last resort, after exhausting the options of seeking help via Canvas and course staff. Even at that point, the best thing to do is to use outside resources partially, to get a sense of a path to the solution, and then to attempt the problem on your own again. If you do read a solution from an external source, I advise you to internalize *how* and *why* the solution works, possibly with the help of office hours. In that situation, write your own solution while not looking at the external source, to ensure you really understood it.

You *must* properly attribute your sources for each problem, even if it is yourself (via “Attribution: self”). For example, if Bob asks Alice for advice on question 3, then Bob would write on their attribution page for question 3: “Attribution: Discussed with Alice”. *You will not lose points for telling the truth.*

Late Homework Assignment Policy Late submissions on homework assignments are allowed for up to a week after the official due date. There are two penalties. First, $5x$ points will be deducted, where x is the number of times you have previously submitted a late assignment. Second, grading may be substantially delayed. Any assignments submitted more than 7 days after the due date will not be graded. Special arrangements will be made in the event of an *excused absence*. Excused absences must be in compliance with University policies in the Graduate Catalog (catalog.ufl.edu/graduate/regulations) and require appropriate documentation.

5.4 Exams

There will be two exams. You are not allowed to consult other people or any online sources for the tests, but you are permitted to use your class notes. Please check the course website for the latest exam schedule.

Exam Make-Up Policy If you are unable to take an exam due to a family or medical emergency, and you notify the instructor in advance of the exam, then a make-up exam will be organized as soon as it is feasible for both you and the instructor.

5.5 Project

At the end of the semester, you will present a research paper from the integer programming literature to the class. You will be given a selection of suggested papers, though you will also be given the opportunity to propose a discrete optimization article to present.

5.6 Regrade Policy

Every student may request a regrade of their assignments and exams. Only one regrade will be considered per assignment/exam. The deadline for requesting a review is one week after the graded work is returned to the class, even if you were not present that day. The request for regrading must be done in writing together with a detailed description of the reasons why you believe there was a mistake in your grade. Note that requesting a regrade implies that the *entire* assignment may be reviewed. This means points could actually be *deducted*.

6 Honor Code

All course participants (myself and students) must abide by the requirements and spirit of the University of Florida Student Honor Code, which can be found at

<https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/>.

Every University of Florida student is subject to the following Honor Pledge:

We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honesty and integrity by abiding by the Student 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.”

You are obligated to report any condition that facilitates academic misconduct to appropriate personnel. Any honor code violations will be handled by the University’s [honor code process](#).

In this course, collaboration on exams is expressly forbidden, as is the exchange of complete answers to homework assignments prior to submission. Please ask if at any point you need clarification regarding the honor code expectations, or you need assistance in any way in complying with the honor code.

7 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 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](#).

8 Course Recording

Instructor Recording of Class Sessions

Class sessions may be audiovisually recorded and made available for private review. **If you participate in class, you acknowledge that your voice and potentially your image, such as your video or profile picture, may be captured on this recording. If you do not consent, you must inform the instructor(s) as soon as possible, to discuss alternatives.** As in all courses, unauthorized recording and unauthorized sharing of recorded materials is prohibited. In particular, you are not permitted to distribute recordings of this class to anyone not enrolled.

Student Recording of Class Sessions

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” 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](#).

9 Accommodations

For students requiring accommodations, please [reach out](#) as early as possible in the semester to discuss how to ensure accessibility for you. You can connect with the Disability Resource Center by visiting disability.ufl.edu/students/get-started; they can provide an accommodation letter, which will assist in understanding your accessibility needs.

10 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 the [Notification to Students of FERPA Rights](#) and visit registrar.ufl.edu/ferpa.

11 Commitment to a Safe and Inclusive Learning Environment

The Herbert Wertheim College of Engineering values varied perspectives and lived experiences within our community and is committed to supporting the University’s core values, including the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of race, creed, color, religion, age, disability, sex, sexual orientation, gender identity and expression, marital status, national origin, political opinions or affiliations, genetic information, and veteran status.

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 Program Coordinator
- HWCOE Human Resources, 352-392-0904, student-support-hr@eng.ufl.edu
- Pam Dickrell, Associate Dean of Student Affairs, 352-392-2177, pld@eng.ufl.edu
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, nishida@ufl.edu

12 Campus Resources

12.1 Health and Wellness

Take care of yourself by paying attention and devoting time to your physical and mental wellbeing. Do not hesitate to reach out to me or a qualified professional if you are ever in need of support. Resources that are available to you include:

- **University Police Department:** 352-392-1111 (call 911 for emergencies).
- **U Matter, We Care:** If you or someone you know is in distress, please contact umatter@ufl.edu or call 352-392-1575 (a nighttime and weekend crisis counselor is available). The U Matter, We Care Team can help connect students to many other helping resources available including, but not limited to, **Victim Services**, Housing Staff, and the **Counseling and Wellness Center**. Please remember that asking for help is a sign of strength. <https://umatter.ufl.edu>
- **Counseling and Wellness Center:** Visit the center or call 352-392-1575 for information on crisis and non-crisis services. <https://counseling.ufl.edu>
- **Student Health Care Center:** Visit the SHCC website or call 352-392-1161 for 24/7 information to help you find the care you need. <https://shcc.ufl.edu>
- **UF Health Shands Emergency Room / Trauma Center:** For immediate medical care call 352-733-0111 or go to the emergency room at 1515 SW Archer Road, Gainesville, FL 32608. <https://ufhealth.org/uf-health-shands-emergency-room-trauma-center>
- **Sexual Discrimination, Harassment, Assault, or Violence** If you or someone you know has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence, contact the **Office of Title IX Compliance**, located at Yon Hall Room 427, 1908 Stadium Road, 352-273-1094, title-ix@ufl.edu. <https://titleix.ufl.edu>
- **Sexual Assault Recovery Services (SARS):** Sexual assault counseling available through the Student Health Center, 352-392-1161.

12.2 Academic Resources

- **e-Learning Technical Support:** 352-392-4357 (option 2) or learning-support@ufl.edu.
- **Career Resource Center:** Career assistance and counseling, Reitz Union, 352-392-1601.
- **Library Support:** Receive assistance with using the libraries or finding resources.
- **Teaching Center:** General study skills and tutoring, Broward Hall, 352-392-2010 or 352-392-6420.
- **Writing Studio:** Help brainstorming, formatting, and writing papers, 302 Tigert Hall, 352-846-1138.
- **The Care Area:** Address student complaints, create success plans and ongoing support for students in distress, and help students complete necessary medical petition paperwork for all courses or medical withdrawals from a course.
- **Distance Learning Complaints:** Student complaints for online distance learning programs.