

CGU Institute of Mathematical Sciences
Topics in Discrete Optimization – Math 389E
Fall 2022

Contact Information

Class Instructor:

Professor Lenny Fukshansky (CMC)
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Office Hours: by appointment, in-person or via Zoom

Teaching Assistant:

Max Forst (CGU)
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Class Schedule

Semester start/end dates: 8/29/2022 – 12/10/2022
Meeting day, time: Th 1:00 – 3:50 pm
Class Location: CGU Math North
Weekly homework discussion sessions: TBA

Course Description

This course will focus on several classical optimization problems and spend a part of the semester on each of them. The specific problems considered may include:

1. ***The Integer Knapsack Problem***: given a collection of objects with assigned weight and cost, maximize the cost function while keeping the weight under the specified threshold. In addition to its intrinsic mathematical significance, this problem often comes up in resource allocation.
2. ***The Frobenius Problem***: given a collection of relatively prime positive integers, find the largest positive integer that cannot be represented as their nonnegative integer linear combination. This problem is closely related to the integer knapsack, and (same as integer knapsack) is known to be NP-hard in general.
3. ***The Main Problem of Coding Theory***: maximize the error-correcting capability of a linear code while keeping its codeword length bounded. This problem is central in the study of accurate data transmission over potentially noisy channels.
4. ***Optimization Problems on Lattices***: optimize packing density, covering thickness and kissing number of a Euclidean lattice in n dimensions. This is the main problem of lattice theory, a branch of mathematics at the intersection of number theory and discrete geometry. In addition to its theoretical value, it has numerous applications, for instance in digital and wireless communications.

5. ***Coherence Minimization on Euclidean Frames***: find frames (overdetermined spanning sets) in Euclidean vector spaces of large cardinality and small coherence. Such frames allow for sufficiently fast data transmission with efficient erasure-recovery capabilities.

These problems have many features in common, in particular all of them have geometric interpretation as well as numerous applications in digital communications. The goal of this course would be to give an introduction to these deep problems, to discuss their unified geometric framework, and to indicate some applications.

Credit/Units: 4

Background Preparation (Prerequisites)

The prerequisites for this course include in-depth knowledge of linear algebra, as well as general familiarity with real analysis and abstract algebra.

Student Learning Outcomes

By the end of this class, students will be able to:

1. Identify, understand and explain the statements of several classical discrete optimization problems.
2. Analyze their level of complexity.
3. Understand and be able to explain some of their applications.
4. Describe the geometric framework behind these problems.

Texts and Journal References

Lecture notes will be posted on the class webpage.

Assignments and Assessments

The assessment will be based on the following combination:

Homework discussion session: 20%

Midterm exam: 40%

Final exam or presentation (to be specified): 40%

The weekly homework discussion session will be led by our TA Max Forst (time and place TBA). The grade for this discussion section will be determined by Max based on attendance, participation, and quality of the presented problem solutions.

Final Grades

Your grade will be calculated using the following scale. Grades with plus or minus designations are at the professor's discretion.

Letter Grade	Grade Point	Description	Learning Outcome
A	4.0	Complete mastery of course material and additional insight beyond course material	Insightful
B	3.0	Complete mastery of course material	Proficient
C	2.0	Gaps in mastery of course material; not at level expected by the program	Developing
U	0	Unsatisfactory	Ineffective

In exceptional circumstances (e.g., illness) that prevent a student from completing assigned coursework, and provided that the student's work to date is satisfactory, the instructor may assign an I (Incomplete) grade along with a date for successful submission of course assignments and requirements.

Continual matriculation at CGU requires a minimum grade point average (GPA) of 3.0 in all coursework taken at CGU. Students may not have more than two incompletes at one time.

CGU policies on grades, including incomplete grades, registration and enrollment can be found on the Registrar's webpage: <http://www.cgu.edu/registrar>.

Class Policies

The CGU institutional policies apply to each class offered at CGU. Students are encouraged to review the student handbook for their program as well as policy documentation in the Bulletin and on the Registrar's webpages: <http://bulletin.cgu.edu/> and <http://www.cgu.edu/registrar>. The protocols defined by the CGU's Student Conduct Code must be upheld in all classes. For more information, please visit for CGU's [Basic Code of Conduct](#) (Links to an external site.).

Credit Hour

Credit hour refers to the units or credits earned by a student for the successful completion of a course at CGU. These are the units recorded on transcripts and the units that are counted toward degree requirements. For CGU courses, a single unit or credit is determined by 10.5 hours of instructional activity per semester. Instructional activity includes direct instructor contact in a physical or virtual classroom as well as asynchronous instructional content for online or hybrid courses. See the full policy [here](#).

Attendance

Students are expected to attend all classes, whether the class is taken for credit or on an audit basis. Students unable to attend a class must seek permission for an excused absence from the instructor or teaching assistant prior to the class meeting. Unapproved absences or late attendance for three or more classes may result in a lower grade or being involuntarily withdrawn from the class (with enrollment refunds governed by CGU's published Academic Calendar). If students have to miss a class, they should arrange to get notes from a fellow student and are strongly encouraged to meet with the teaching assistant to obtain the missed material. Missed extra-credit quizzes and papers are not available for re-taking.

Scientific and Professional Ethics

The work you do in this class must be your own. Feel free to build on, react to, criticize, and analyze the ideas of others but, when you do, make it known whose ideas you are working with. You must explicitly acknowledge when your work builds on someone else's ideas, including ideas of classmates, professors, and the authors you read. If you ever have questions about drawing the line between others' work and your own, ask the instructor for guidance. Exams must be completed independently and without using cell phones, tablets, or computers to search or retrieve material. Any collaboration on answers to exams, unless expressly permitted by the instructor, may result in an automatic failing grade and possible expulsion from the program.

Additional information on CGU's Policy and Procedures for Violations of Standards of Academic Integrity can be found at: <https://cgu.policystat.com/policy/3903703/latest/>. In addition, the Claremont Colleges Library has a number of resources on academic honesty and integrity, including the following online tutorial: <https://library.claremont.edu/exploring-academic-integrity/>

Standards of Appropriate Behavior for Online Courses

Web based programs define the area in view of the camera as part of the classroom. Students must therefore present themselves and their surroundings as much as possible as though they are in a physical classroom. Attending class remotely, you can easily forget that your home environment is fully visible and can be distracting to you and your classmates. Here are some guidelines to help you to be more intentional and effective in how you attend class online:

Appropriate Dress: Even though you are at home, dress in casual professional attire for class so that you present yourself appropriately to your instructor and peers on camera. Remember, there is no back row in a video meeting. What you wear is amplified and speaks loudly!

Location: Attend class in a location that allows for your full attention and participation. Aim to be on-camera in an environment free of auditory or visual distractions, and that allows for open, focused participation in class discussion. While home situations differ and some interruptions might be unavoidable, aim for the following:

- Be mindful of your background. Your camera captures you and anything in your background, so find a background that is appropriate to be viewed by your classmates. You can always set up a virtual background in Zoom that will hide the real background in your location.
- Stay on camera – leaving the camera frequently or for extended periods of time disengages you and others from class work.
- Make prior arrangements with family members to give you dedicated uninterrupted space and time for the duration of each class meeting. Avoid public locations, especially locations that are noisy and distracting or where you cannot freely speak to engage in discussions.

- Stay focused. Avoid the following to the extent you are able: Interacting with persons not part of the class, behaving in an overly inattentive manner, multi-tasking with non-class related work.

We understand that you may have challenges with caregiving or finding a distraction-free space for the duration of each class meeting. Please speak with your professor about this so that we can work out ways to optimize your engagement and reduce interruption and distractions.

Other Resources

Accommodations for Students with Disabilities

CGU is committed to creating courses that are inclusive and accessible. If you would like to request academic accommodations due to temporary or permanent disability, contact the CGU Dean of Students and Coordinator for Student Disability Services at DisabilityServices@cgu.edu or (909) 607-9448. Reasonable accommodations are considered after you have conferred with the Office of Disability Services (ODS) and presented the required documentation of your disability to the ODS. Planning is essential, so please communicate to the ODS as soon as possible.

Mental Health Resources

Graduate school is a context where mental health struggles can arise or be exacerbated. If you ever find yourself struggling, please ask for help. If you wish to seek out campus resources, here is some basic information: services.claremont.edu/mcaps/

Monsour Counseling and Psychological Services (MCAPS) is committed to promoting psychological wellness for all students at The Claremont Colleges. Professional and well-trained psychologists, psychiatrists, and post-doctoral and intern therapists offer support for a range of psychological issues in a confidential and safe environment.

Phone (909) 621-8202

After hours emergency (909) 607-2000

Tranquada Student Services Center, 1st floor

757 College Way

Claremont, CA 91711

Title IX

One of my responsibilities as an instructor is to help create a safe learning environment. I am a mandatory reporter. Thus, if I learn of any potential violation of CGU's gender-based misconduct policy (e.g., rape, sexual assault, dating violence, domestic violence, or stalking) by any means, I am required to notify the CGU Title IX Coordinator at Deanof.Students@cgu.edu or (909) 607-9448. Students can request confidentiality from the institution, which I will communicate to the Title IX Coordinator. If students want to speak with someone confidentially, the following resources are available on and off campus: EmPOWER Center (909) 607-2689, Monsour Counseling and Psychological Services (909) 621-8202, and The Chaplains of The Claremont Colleges (909) 621-8685. Speaking with a confidential resource does not preclude students from making a formal report to the Title IX Coordinator if and when they are ready. Confidential resources can walk students through all of their reporting options. They can also provide students with information and assistance in accessing academic, medical, and other support services they may need.

Campus Security

Campus security can be reached 24 hours/day at (909) 607-2000. Please download the [CGU Safety Resource Card](#) to your phone's contacts.

Office of Information Technology (OIT)

The Office of Information Technology has a helpdesk to support you with CGU wireless access and email issues. They also have good documentation you can use to learn to connect and use online resources. **Website:** <https://mycampus.cgu.edu/web/it>

Center for Writing and Rhetoric (CWR)

CGU has a graduate studies-focused Center for Writing and Rhetoric that works with you no matter where you are in the writing process. The CWR is not just for remediation of your writing, but for all writers to provide partnership and consultation to improve your academic work at all levels. The CWR can work with you in planning, outlining, drafting, and final review of documents and presentations for class work, conferences, and publications. **Website:** <https://mycampus.cgu.edu/web/writing-rhetoric>

The Claremont Colleges Library

The Claremont Colleges Library has a wealth of resources, including subject specialist librarians, to support your academic work. Use the library for class work and research to access and use databases for articles, books, and data sets, to understand how to conduct effective searches and evaluate sources, use digital tools, and much more. The library offers workshops and 1-1 consultations with students as well. **Website:** <https://library.claremont.edu/>