UAB
Universitat Autònoma de Barcelona

2020/2021

Discrete mathematics seminar

Code: 100098
ECTS Credits: 6

Degree	Type	Year	Semester
2500149 Mathematics	OB	2	1

The proposed teaching and assessment methodology that appear in the guide may be subject to changes as a result of the restrictions to face-to-face class attendance imposed by the health authorities.

Contact

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Use of Languages

Principal working language: catalan (cat)

Some groups entirely in English: No

Some groups entirely in Catalan: Yes

Some groups entirely in Spanish: No

Prerequisites

BMath first year courses Linear Algebra-100088 and Fundamental Mathematics-100089.

Objectives and Contextualisation

Discrete Mathematics is a field of mathematics that studies finite mathematical objects. It covers topics such as combinatorics, graph theory, cryptography, error-correcting codes, combinatorial design theory, game theory, logic, optimization, or algorithm design and analysis that can be applied to solve problems in any of the above-mentioned branches. Most of discrete mathematics has evolved relatively recently, motivated by the challenges mainly in computer science and operations research. The chapters of this introductory course are quite independent from one another. A prior knowledge of linear algebra, modular arithmetic, basic combinatorics, and -fundamentally- mathematical language and reasoning should be adequate to understand the subject matter of each chapter.

The first chapter addresses the topic of generating functions and recurrent sequences, this being a natural next step following the elementary combinatorics studied in the first year course Fundamental Mathematics. Once again, problems in combinatorics require training the skill of formulating a problem in terms of a mathematical statement. The second chapter deals with graphs, which are a fundamental tool for problem solving in quite different settings, ranging from the most abstract mathematics up to operations research. In some cases, a graph-theoretical formulation of the problem turns out to be, in itself, illuminating and a highly efficient step towards the solution.

The last chapter tackles the topic of linear programming, whose goal is to optimize linear functions of several variables subject to linear constraints. Although the subject shows a hybrid continous/discrete nature, it is often taught along with other discrete math disciplines. The theory behind linear programming involves basic linear algebra techniques. While appearing simple, the methods explained in class apply to a wide collection of complex real world problems. Some of them require integer and binary variables and are among the most interesting.

In summary, throughout this course in discrete mathematics, a variety of examples and applications will be explained, where by means of relatively simple tools and a clever approach, we get to solve interesting and

difficult problems. Moreover, by their work on problem sets, students will be able to practice the first step in the process of mathematical modeling, namely, understanding a problem and finding a suitable mathematical formulation that leads to the solution.

Competences

- Actively demonstrate high concern for quality when defending or presenting the conclusions of ones work.
- Apply critical spirit and thoroughness to validate or reject both ones own arguments and those of others.
- Effectively use bibliographies and electronic resources to obtain information.
- Students must be capable of applying their knowledge to their work or vocation in a professional way and they should have building arguments and problem resolution skills within their area of study.
- Students must be capable of communicating information, ideas, problems and solutions to both specialised and non-specialised audiences.
- Students must develop the necessary learning skills to undertake further training with a high degree of autonomy.
- Students must have and understand knowledge of an area of study built on the basis of general secondary education, and while it relies on some advanced textbooks it also includes some aspects coming from the forefront of its field of study.
- Use computer applications for statistical analysis, numeric and symbolic calculus, graphic display, optimisation or other purposes to experiment with Mathematics and solve problems.
- When faced with real situations of a medium level of complexity, request and analyse relevant data and information, propose and validate models using the adequate mathematical tools in order to draw final conclusions

Learning Outcomes

1. Actively demonstrate high concern for quality when defending or presenting the conclusions of ones work.
2. Apply critical spirit and thoroughness to validate or reject both ones own arguments and those of others.
3. Consider and resolve linear programming problems.
4. Consider ordering and enumeration problems and use efficient techniques to resolve them.
5. Consider real problems as Mathematical Programming problems.
6. Effectively use bibliographies and electronic resources to obtain information.
7. Students must be capable of applying their knowledge to their work or vocation in a professional way and they should have building arguments and problem resolution skills within their area of study.
8. Students must be capable of communicating information, ideas, problems and solutions to both specialised and non-specialised audiences.
9. Students must develop the necessary learning skills to undertake further training with a high degree of autonomy.
10. Students must have and understand knowledge of an area of study built on the basis of general secondary education, and while it relies on some advanced textbooks it also includes some aspects coming from the forefront of its field of study.
11. Understand the language and most elementary applications of graph theory, as well as algorithms for problem-solving with graphs.
12. Use computational techniques to solve optimisation problems.

Content

1. Generating functions and recurrent sequences.

- Generating function definition. Computation techniques. Solving combinatorial problems using generating functions.

- Recurrent sequences. First and second order linear recurrence relations.

- Solving recurrence relations with generating functions.

2. Graph Theory.

- Definition and examples of mathematical modeling using graph theory.

- Basic concepts. Some graph families.

- Graph representation, graph isomorphism.

- Paths and cycles.

- Trees.

3. Linear Programming.

- Introduction. Some examples.

- Mathematical model. Basic concepts and main results.

- The simplex method.

4. Brief Introduction to other topics in Discrete Mathematics(Student-presented Seminar).

Topics may include combinatorial designs, cryptography, planar graphs, Hamiltonian graphs, Random graphs, Coding theory, Ramsey theory, Game theory, etc...

Methodology

Classroom activities change over the course:

-Lectures and Problem Sets are planned for the first two chapters. In order to benefit from the class discussion, students should come to Problem-Set class meetings after having prepared the corresponding assignments.

- Lectures, Problem Sets, and Computer Labs are scheduled for chapter 3. In Computer-Lab sessions we learn how to use the linear programming kit GLPK, where problems can be modeled in the *GNU MathProg* (a subset of AMPL).

-One month after the course begins, students start working on their presentations. The class is divided into teams of four students each. A presentation topic approved by the instructor is assigned to each team. Teams work on their own and prepare a short study guide including a table of contents, definitions, the most relevant results, and references. Student-presented lectures are scheduled for the last two or three weeks of class.

Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Computer Lab	8	0.32	
Lectures	28	1.12	
Problem Set meetings	16	0.64	7
Type: Supervised			
Meeting with instructor for feedback on the seminar project	1	0.04	10, 9, 8
Type: Autonomous			

Group meetings for study/preparation for the Student-presented Seminar	14	0.56	10, 9, 8
Individual practice on the linear programming software	8	0.32	7
Self-study of lecture material	26	1.04	10, 9, 7
Working on problem sets	36	1.44	7

Assessment

There are four graded tasks: a midterm exam, a computer lab test, a seminar project, and a final exam.

Course grade is calculated according to the following formula:

0.15 midterm exam score + 0.2 computer lab test score + 0.15 seminar project score+ 0.5 final exam score

The final exam is cumulative. A student missing the midterm exam due to medical or other excuses should submit documented evidence to be eligible for a make-up exam.

Exam Retake Option: There is only one possible retake for the final exam(50%). To be eligible to retake the final exam you should have participated, at least, in three graded tasks.

Participating in less than three graded tasks and not taking the final exam will result in a "Non-assessable" course grade.

After the final exam, course grades with distinction/honors are granted to those students whose work clearly merits it. Students retaking the final exam to improve their score may also apply for consideration for distinction.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Computer Lab test	0.2	2	0.08	3, 4, 12
Final exam	0.5	4	0.16	11, 3, 4, 5
Grading of the student-presented seminar (presentation and study guide)	0.15	1	0.04	2, 1, 10, 9, 8, 7, 6
Midterm exam	0.15	2	0.08	11, 3, 4, 5, 7
Retake exam	0.5	4	0.16	11, 3, 4, 5

Bibliography

Recommended textbooks:

Basart, J.M. , Rifà, J, and Villanueva, M. "Fonaments de matemàtica discreta. Elements de combinatòria i d'aritmètica". Col. Materials de la UAB, n. 36. 1997.

Graham, R.L. , Knuth, D. E. , and Patashnik, O. "Concrete mathematics: a foundation for computer science". Addison-Wesley. 1990.

Grimaldi, Ralph P. "Discrete and combinatorial mathematics: an applied introduction". 5th ed. Pearson.Addison-Wesley. 2004.

Rosen, Kenneth H. "Discrete mathematics and its applications". 6th ed. McGraw-Hill. 2007.

Suggested Readings on Graph Theory:

Bondy, J.A. , and Murty, U.S.R. "Graph Theory". Springer. 2008.

Wilson, R.J. , and Watkins, J. "Graphs: an introductory approach: a first course in discrete mathematics". Wiley, cop. New York. 1990.

Suggested Readings on Linear Programming:

Alabert, A. , and Camps, R. "Programació Lineal, una introducció a la presa de decisions racional".

Basart, J.M. "Programació lineal". Col. Materials de la UAB, n. 58.. 1998.

Luenberger, D. , and Ye, Y. "Linear and Nonlinear Programming". 3rd ed. Springer. 2008.