DISCRETE MATHEMATICS

Bachelor in Applied Mathematics BAM SEP-2023 DM-AM.1.S.A

Area Others

Number of sessions: 30

Academic year: 23-24

Degree course: FIRST

Number of credits: 6.0

Semester: 1º

Category: BASIC

Language: English

Professor: **SIMÓN ISAZA**

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Simón Isaza has a PhD. in Mathematical Research by Complutense University of Madrid. He completed these studies founded by an FPI scholarship and graduated “cum laude”. His thesis “CW Decompositions of Algebraic Curves and Milnor Fibers of Non-Isolated Quasi-Ordinary Singularities” treated about themes in Topology and Theory of Singularities. He has worked in teaching and research at the National University of Colombia, Complutense University, and currently at IE University. He also has experience as financial risk consultant at KPMG. He is passionate about technology, economics, and knowledge in general.

Education:

- Ph.D in Mathematics, Universidad Complutense de Madrid.
- MSc. In Mathematics, Universidad Nacional de Colombia.
- BSc. In Mathematics, Universidad Nacional de Colombia.

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SUBJECT DESCRIPTION

In this course you will learn about the basic concepts of logic (propositional logic, proof methods, set theory, relations, and recursive functions) along with some very useful algebraic concepts (basic combinatorics and graph theory). These concepts are not only fundamental to physics, computing and many areas having vast numbers of applications, but they also lie in the very basis of mathematics and knowledge itself.

Throughout the course you will work with the mathematical concepts alongside real-world examples from programming, science, engineering and economics. In this way you will acquire, on the one hand, a knowledge that is essential to computer algorithms and wide variety of applications. And, on the other hand, and a more abstract tool that will allow you to approach problems in a deep, structured, and fundamental way, which is a core asset for an applied mathematician.

LEARNING OBJECTIVES

- To understand and be able to use the basic concepts of propositional logic, predicate logic, and proof methods.
- To understand and learn to apply the main concepts of set theory, relations, counting techniques and combinatorics.
- To become proficient in the use of recursive functions, sets and algorithms.
- To understand the different kinds of relations and orderings.
- To acquire a basic knowledge of graph theory, its main concepts and its application.

TEACHING METHODOLOGY

The teaching methodology for this course includes lectures, discussions, exercises, group work, home work, and individual studying. Lectures will cover theoretical explanations followed by practical applications and exercises. Discussions or group work can also be included after these activities or in-between.

Students are expected to review and study each session thoroughly before the next one. This is a very important aspect of the learning process and will be key to their success. They are also encouraged to ask their questions to the teacher and to discuss with their classmates.

IE University teaching method is defined by its collaborative, active, and applied nature. Students actively participate in the whole process to build their knowledge and sharpen their skills. Professor's main role is to lead and guide students to achieve the learning objectives of the course. This is done by engaging in a diverse range of teaching techniques and different types of learning activities such as the following:

Learning Activity	**Weighting**	**Estimated time a student should dedicate to prepare for and participate in**
Lectures	20.0 %	30.0 hours
Discussions	13.33 %	20.0 hours
Exercises in class, Asynchronous sessions, Field Work	20.0 %	30.0 hours
Group work	20.0 %	30.0 hours
Individual studying	26.67 %	40.0 hours
TOTAL	100.0 %	150.0 hours

PROGRAM

Disclaimer: The following description of the material covered is tentative. While an attempt will be made to cover all listed topics and include other advanced topics that will help students throughout their careers in applied mathematics, the pace of the classes will depend on group performance, which may introduce some variations in the syllabus.

MODULES

- Propositional Logic.
- Basic counting techniques. Combinatorics.
- Recursion.
- Binary relations.
- Graph theory and applications.

SESSION 1 (LIVE IN-PERSON)

- Introduction to the course.
- First definitions (proposition, conjunction, implication, converse, contrapositive and inverse, biconditional statement).
- Truth tables.

SESSION 2 (LIVE IN-PERSON)

- Logical equivalences.
- De Morgan's Laws.
- Satisfiability.

SESSION 3 (LIVE IN-PERSON)

- Predicates.
- Quantifiers and nested quantifiers.

SESSION 4 (LIVE IN-PERSON)

- Introduction to proofs.
- Proof Methods.

SESSION 5 (LIVE IN-PERSON)

- Finish Module 1 (if needed).
- Review of Module 1.

SESSION 6 (LIVE IN-PERSON)

- Basics of Set Theory.
- Basic counting techniques: lists, sets, multisets, sum and product rules.

SESSION 7 (LIVE IN-PERSON)

- Principle of Inclusion and Exclusion.
- The Pigeonhole Principle and applications.

SESSION 8 (LIVE IN-PERSON)

- Permutations and Combinations.
- Generalized permutations and combinations.
- Boxes and objects.

SESSION 9 (LIVE IN-PERSON)

- Binomial coefficients and identities.
- Multinomial coefficients.
- Partitions I.

SESSION 10 (LIVE IN-PERSON)

- Partitions II.
- Recursively defined functions.
- Recursively defined sets.

SESSION 11 (LIVE IN-PERSON)

- Recursive algorithms.

SESSION 12 (LIVE IN-PERSON)

- Recurrences.
- Solving linear recurrence equations.

SESSION 13 (LIVE IN-PERSON)

- Review for midterm.

SESSION 14 (LIVE IN-PERSON)

- Midterm exam.

SESSION 15 (LIVE IN-PERSON)

- Solving the midterm exam.
- Introduction to relations.

SESSION 16 (LIVE IN-PERSON)

- Relations and their properties.
- Representing relations.

SESSION 17 (LIVE IN-PERSON)

- Equivalence relations.
- Partial orderings.

SESSION 18 (LIVE IN-PERSON)

- Congruences.
- Fermat’s Little Theorem.

SESSION 19 (LIVE IN-PERSON)

- Graphs and graphs models.
- Main parameters of a graph.
- Basic results.

SESSION 20 (LIVE IN-PERSON)

- Isomorphic graphs.
- Special types of graphs.
- Bipartite graphs.
- Matchings.

SESSION 21 (LIVE IN-PERSON)

- Trees and forests.
- Spanning trees.

SESSION 22 (LIVE IN-PERSON)

- Euler paths.
- Hamilton paths.
- Hamilton cycles.

SESSION 23 (LIVE IN-PERSON)

- Graph colouring.
- Chromatics polynomial.

SESSION 24 (LIVE IN-PERSON)

- Connectivity.
- Edge connectivity.

SESSION 25 (LIVE IN-PERSON)

- Planar graphs.

SESSION 26 (LIVE IN-PERSON)

- Introduction to algorithms over graphs.

SESSION 27 (LIVE IN-PERSON)

- A nice application: Games and strategies.

SESSION 28 (LIVE IN-PERSON)

- Review.

SESSION 29 (LIVE IN-PERSON)

- Review.

SESSION 30 (LIVE IN-PERSON)

- Final exam.

EVALUATION CRITERIA

criteria	percentage	Learning Objectives	Comments
Final Exam	30 %		To take place on session 30.
Intermediate tests	30 %		Midterm and quizzes. Midterm is going to take place on session 14.
Exercises	30 %		Group work and home work.
Class Participation	10 %		Students are expected to participate actively during lectures with questions and remarks. Class grade will be based also on punctuality, participation, and class conduct. There may be a penalty if you create a disruption or talk excesively during class.

RE-SIT / RE-TAKE POLICY

Each student has four chances to pass any given course distributed over two consecutive academic years: ordinary call exams and extraordinary call exams (re-sits) in June/July.

Students who do not comply with the 80% attendance rule during the semester will fail both calls for this Academic Year (ordinary and extraordinary) and have to re-take the course (i.e., re-enroll) in the next Academic Year.

Evaluation criteria:

•Students failing the course in the ordinary call (during the semester) will have to re-sit the exam in June / July (except those not complying with the attendance rule, who will not have that opportunity and must directly re-enroll in the course on the next Academic Year).

• The extraordinary call exams in June / July (re-sits) require your physical presence at the campus you are enrolled in (Segovia or Madrid). There is no possibility to change the date, location or format of any exam, under any circumstances. Dates and location of the June / July re-sit exams will be posted in advance. Please take this into consideration when planning your summer.

• The June / July re-sit exam will consist of a comprehensive exam. Your final grade for the course will depend on the performance in this exam only; continuous evaluation over the semester will not be taken into consideration. Students will have to achieve the minimum passing grade of 5 and can obtain a maximum grade of 8.0 (out of 10.0) – i.e., “notable” in the in the re-sit exam.

• Retakers: Students who failed the subject on a previous Academic Year and are now re-enrolled as re-takers in a course will be needed to check the syllabus of the assigned professor, as well as contact the professor individually, regarding the specific evaluation criteria for them as retakers in the course during that semester (ordinary call of that Academic Year). The maximum grade that may be obtained in the retake exam (3rd call) is 10.0.

After ordinary and extraordinary call exams are graded by the professor, you will have a possibility to attend a review session for that exam and course grade. Please be available to attend the session in order to clarify any concerns you might have regarding your exam. Your professor will inform you about the time and place of the review session. Any grade appeals require that the student attended the review session prior to appealing.

Students failing more than 18 ECTS credits after the June-July re-sits will be asked to leave the Program. Please, make sure to prepare yourself well for the exams in order to pass your failed subjects.

In case you decide to skip the opportunity to re-sit for an exam during the June / July extraordinary call, you will need to enroll in that course again for the next Academic Year as a re-taker and pay the corresponding extra cost. As you know, students have a total of four allowed calls to pass a given subject or course, in order to remain in the program.

BIBLIOGRAPHY

Recommended

- Biggs, N.. *Discrete Mathematics.* OUP Oxford. ISBN 0198507178 (Digital)

- Rosen, K.. *Discrete mathematics and its applications.* McGraw Hill Education. ISBN 9780070681880 (Digital)

- Johnsonbaugh, R.. *Discrete Mathematics.* Prentice Hall. ISBN 0131593188 (Digital)

PREREQUISITES

The prerequisite for the course is proficiency in basic arithmetic and algebra, as studied in high school (fractions, exponents, radicals, logarithms, factorization, quadratic equations, systems of equations, inequalities).

BEHAVIOR RULES

Please, check the University's Code of Conduct here. The Program Director may provide further indications.

ATTENDANCE POLICY

Please, check the University's Attendance Policy here. The Program Director may provide further indications.

ETHICAL POLICY

Please, check the University's Ethics Code here. The Program Director may provide further indications.