Universidad Zaragoza

Academic Year/course: 2022/23

26958 - Graphs and Combinatorics

Syllabus Information

Academic Year: 2022/23
Subject: 26958 - Graphs and Combinatorics
Faculty / School: 100 - Facultad de Ciencias
Degree: 447 - Degree in Physics
ECTS: 6.0
Year: 1
Semester: Second semester
Subject Type: Optional
Module:

1. General information

1.1. Aims of the course

This course is an introduction to discrete mathematics. The topics presented are grouped into units and include enumerative combinatorics, generating functions, graphs and the main basic algorithms on graphs.

These approaches and objectives are aligned with the following Sustainable Development Goals (SDGs) of the United Nations 2030 Agenda (https://www.un.org/sustainabledevelopment/es/), in such a way that the acquisition of the learning outcomes of the module provides training and competence to contribute to some extent to their achievement:

- (4) Quality education
- (5) Gender equality
- (8) Decent work and economic growth
- (9) Industry, innovation and infrastructure
- (10) Reducing inequality
- (17) Partnerships for the goals.

1.3. Recommendations to take this course

Attend all the classes. Work (and write) a lot of exercises.

During an average week, students were expected to spend 10 hours on the course, roughly divided as follows:

2 hours of theory sessions.

2 hours of problems sessions.

6 hours of study, realization and writing of exercises.

2. Learning goals

2.1. Competences

On completion of this subject, students will be able to explain and apply the basic methods of discrete (noncontinuous) mathematics. They will be able to use these methods in subsequent courses on Mathematics and on Algorithmics.

2.2. Learning goals

Understanding of topics in discrete mathematics.

Dominate technical aspects on counting and graph theory.

3. Assessment (1st and 2nd call)

3.1. Assessment tasks (description of tasks, marking system and assessment criteria)

Grading.

There will be one 2-hour midterm exam only on Combinatorics topics. Each student will get a mark, **P1**, in the range 0 to 10.

In the 4-hour final exam, there will be two parts, one with questions on Combinatorics, the other one with questions about Graph theory. The marks, **E1** and **E2**, obtained in each part will be also in the range 0 to 10.

The final grade, **C**, will be either **C = 0.5*(E1+E2)** if **P1<4** or

C=0.5*(Max(P1,E1)+E2) if **P1>=4**.

4. Methodology, learning tasks, syllabus and resources

4.1. Methodological overview

The methodology followed in this course is oriented towards the achievement of the learning objectives. A wide range of teaching and learning tasks are implemented, such as lectures, problem-solving sessions and tutorials.

4.2. Learning tasks

This course is organized as follows:

- **Lectures** (30 hours). Two weekly sessions of 1 hour each.
- **Problem-solving sessions** (30 hours). Two weekly sessions of 1 hour each. Material covered in exercises will be tested on exams.
- **Tutorials.** The students can attend office hours and send questions to him/her teacher via email.

The teaching activities and assessment tasks will take place in a face-to-face mode, except in the case that, due to the health situation, the dispositions emitted by the competent authorities and by the University of Zaragoza compel to take them to a greater or lesser extent in a telematic form.

4.3. Syllabus

This course covers elementary discrete mathematics. It emphasizes mathematical definitions and proofs as well as applicable methods.

This course will address the following topics:

Section I

- **Topic 1.** Enumerative combinatorics: permutations and combinations.
- **Topic 2.** Binomial coefficients and binomial formula.
- **Topic 3.** Recurrence relations. Some applications.
- **Topic 4.** The inclusion-exclusion principle. Applications.

Section II

- **Topic 5.** Generating functions.
- **Topic 6.** Rational generating functions.

Section III

- **Topic 7.** Graphs: definitions and notation.
- **Topic 8.** Traversing a graph. Algorithms BFS and DFS.
- **Topic 9.** Applications of graph traversal: connected components, strong components, bases.
- **Topic 10.**The number of trees and paths of a graph.

Section IV

- **Topic 11.** Weighted graphs. Algorithms for the minimum spanning tree problem.
- **Topic 12.** The shortest path problem. Dijkstra's algorithm.
- **Topic 13.** PERT-CPM algorithms for scheduling a set of project activities.

Section V

- **Topic 14.** Maximum flow in a network.
- **Topic 15.** The Ford- Fulkerson method for calculating a maximum flow.
- **Topic 16.** Menger?s theorems on connectivity of graphs.
- **Topic 17.** Maximum matching in bipartite graphs. Hall's theorem.
- **Topic 18.** Some NP-Hard problems on graphs.

4.4. Course planning and calendar

Further information concerning the timetable, classroom, office hours, assessment dates and other details regarding this course will be provided on the first day of class or please refer to the Faculty of Sciences website and Moodle.

4.5. Bibliography and recommended resources

Bibliography.

Main:

- Lecture notes of the course at Moodle platform

Complementary:

http://psfunizar10.unizar.es/br13/egAsignaturas.php?codigo=27005