ESCI upf.
School of International Studies

Academic Year/course: 2021/22

52114 - Discrete Mathematics and Optimisation

TEACHING PLAN

1. Basic description

Name of the course: Discrete Mathematics and Optimisation
Academic year: 2021/2022
Year: 2nd
Term: 1st
Code: 52114
Number of credits: 4 credits
Total number of hours committed: 40 hours
Teaching language: English
Lecturer: Oriol Serra and Clément Requilé
Timetable: See official calendar

2. Presentation of the course

This course looks at the main optimisation tools used in numerical mathematics, from the point of view of both continuous and discrete problems. This calls for a deep understanding of graphs and combinatorial problems.

3. Competences to be worked in the course

The above competencies interrelate with the basic competencies set out in Royal Decree 1393/2007, namely:

1. Competence to **comprehend knowledge, on the basis of general secondary education**
2. Competence to **apply knowledge** to day-to-day work in international management or marketing, in particular, ability to develop and defend arguments and to solve problems
3. Competence to **gather and interpret** relevant **data**, enabling the development of critical judgements on the economic and social reality
4. Competence to **communicate and transmit information** (ideas, problems, solutions) to a specialised and non-specialised public.
5. Competence to **develop learning activities** in a relatively autonomous manner.

In order to establish a correspondence between the basic competencies and those developed in the degree, these are grouped according to two criteria. Thus, the competencies developed in the subject are structured into those that are seen as a development or specification of basic competencies and those that define the professional profile of the graduate, with respect to general and specific competencies.

1. *General competencies*

- CB1. That the students have demonstrated to have acquired the knowledge and understanding in a field of study that starts from the basis of general secondary education, and is typically at a level that although it is supported by advanced textbooks, includes some aspects that involve knowledge of the forefront of their field of study.
- CB2. That the students know how to apply their knowledge to their work or vocation in a professional manner and have competencies typically demonstrated through devising and defending arguments and solving problems within their field of study.
- CB4. That the students can convey information, ideas, problems and solutions to both specialist and

non-specialist audiences.

- CB5. That the students have developed those skills needed to undertake further studies with a high degree of autonomy
- CG1. That the students will acquire an intra- and interdisciplinary training in both computational and scientific subjects with a solid basic training in biology.

1. *Transversal competencies*

- CT1. Mastering oral and written communication in English.

1. *Specific competencies*

- CE2. To manage and exploit all kinds of biological and biomedical information to transform it into knowledge
- CE5. To apply mathematical foundations, algorithmic principles and computational theories in the modeling and design of biological systems.
- CE8. To identify meaningful and reliable sources of scientific information to substantiate the state of arts of a bioinformatic problem and to address its resolution.
- CE9. To apply statistical and computational methods to solve problems in the fields of molecular biology, genomics and medical research and population genetics.

Learning outcomes

- RA2.1. Visualize, manipulate and extract biological data.
- RA2.2 Improve understanding of disease onset and progression.
- RA5.1. Recognize and use the basic tools of mathematical language.
- RA5.2. Apply mathematical and statistical treatment to large amounts of biological data.
- RA5.3. Model biological information in mathematical language for further analysis and processing.
- RA8.1. Use efficiently specific search tools and resources from databases and information related to biomedicine and bioinformatics.
- RA8.2. Quote valid sources of scientific information to support the state of the arts of a bioinformatic problem.
- RA9.1. Identify and use appropriate statistical methods to each type of data.
- RA9.2. Use the appropriate methods for complex data, with an emphasis on dimensionality reduction approximations.

During the academic year, if exceptional circumstances force the degree teaching to go for a remote (fully or partially), this subject will adapt to the new situation maintaining the quality of the learning outcomes.

4. Contents

- Basic description of contents outlined for the curriculum

Graph theory and algorithms; basic counting; linear programming; basics of multivariable differential calculus; non-linear optimization.

- Expanded description

1. Basic counting. Selections, multisets, binomial numbers. Recurrences. Solution of linear recurrences with constant coefficients.
2. Graphs and digraphs. Representation of graphs. Exploring graphs. Trees. The Minimum Spanning Tree and Travelling Salesman problems.
3. Linear programming. Modelling using LP. The geometric viewpoint. Duality. The simplex algorithm.
4. Multilinear calculus. The gradient and the Hessian. Extremes values.
5. Non-linear optimization. Convex optimization. Gradient descent. Newton's method.

The course will include practical sessions using python.

5. Assessment

Prerequisites

1st year courses on Algebra and Calculus.

Assessment

The subject will be assessed by means of compulsory assessment elements which will consist of individual exams (Midterm and Final, see (1), (2) in the Table below) and four compulsory tests or deliveries along the course to check the learning process of the students (see (3) in the table below). The weight of the exams is 35% each one and the weight of the tasks is 30%.

Assessment elements	Time period	Type of assessment		Assessment agent			Type of activity	Grouping		We (%
		Comp	Opt	Lecturer	Self-assess	Co-assess		Indiv	Group (#)	
(1) Assessment o n combinations and graph theory	Week 6	x		X			Conceptual and pursuit of the subject			35
(2) Assessment on optimization	Week 11	x		X			Conceptual and pursuit of the subject			35
(3) Assesment on the practical part of the course	Week 5-9	x		X			Application based			30

Extraordinary exam

An extraordinary exam will take place according to the schedule fixed by the Degree Coordination. Failure to attend this exam implies student will keep his initial score.

Working competencies and assessment of learning outcomes:

All the assessments apply to all the competences

6. Bibliography and teaching resources

- Basic bibliography

J. Matousek, J. Nesetril. An Invitation to Discrete Mathematics. Oxford University Press, 2008 (Spanish translation Invitación a la matemàtica discreta, Reverté, 2008).

B. Guenin, J. Könemann, L. Tunçel. A Gentle Introduction to Optimization.
Cambridge University Press, 2014.

J. Kleinberg and E. Tardos. Algorithm design. Addison-Wesley 2005.

- Teaching resources

Phython 3

7. Methodology

Theoretical sessions will be based on slide and blackboard discussions.

Practical sessions will consist of problem solving and computational sessions.

8. Scheduled activities

2h theoretical sessions and 2h practical sessions per week (10 weeks).

La còpia i/o plagi total o parcial als treballs i/o exàmens comportarà suspendre l'assignatura amb una qualificació de zero sense dret a recuperació, sense perjudici de l'aplicació de les altres sancions previstes al Reglament de Règim disciplinari dels estudiants de la Universitat Pompeu Fabra en funció de la gravetat de la infracció.

La copia y/o plagio total o parcial en los Trabajos y/o exámenes comportará suspender la asignatura con una calificación de cero sin derecho a recuperación, sin perjuicio de la aplicación de las otras sanciones previstas en el Reglamento de Régimen disciplinario de los estudiantes de la Universitat Pompeu Fabra en función de la gravedad de la infracción.

Total or partial copy and/or plagiarism will imply a failure in the subject with a final grade of zero points and no access to the make-up exam. According to the academic regulations specified in the Disciplinary rules for students of Universitat Pompeu Fabra, other additional sanctions may apply depending on the seriousness of the offence.