



# Course guide

## 230375 - GSP - Graph Signal Processing

**Last modified:** 24/05/2024

**Unit in charge:** Barcelona School of Telecommunications Engineering  
**Teaching unit:** 739 - TSC - Department of Signal Theory and Communications.

**Degree:** MASTER'S DEGREE IN TELECOMMUNICATIONS ENGINEERING (Syllabus 2013). (Optional subject).  
MASTER'S DEGREE IN ADVANCED TELECOMMUNICATION TECHNOLOGIES (Syllabus 2019). (Optional subject).

**Academic year:** 2024    **ECTS Credits:** 3.0    **Languages:** English

### LECTURER

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**Coordinating lecturer:** Consultar aquí / See here:

**Others:** Consultar aquí / See here:

### PRIOR SKILLS

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Basic knowledge of matrix analysis, Fourier transform, and signal filtering.  
Basic Matlab programming skills.

### DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

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**Specific:**

CE1. Ability to apply information theory methods, adaptive modulation and channel coding, as well as advanced techniques of digital signal processing to communication and audiovisual systems.

**Transversal:**

CT4. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

CT5. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.

### TEACHING METHODOLOGY

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- Theoretical lectures.
- Practical individual sessions in Matlab, and presentation of proposed problems.
- Practical sessions in groups and presentation of a report.

### LEARNING OBJECTIVES OF THE SUBJECT

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Graphs are useful for representing data obtained in numerous applications such as, for example, traffic evolution in a transport network, temperature values in different geographic locations, information dissemination in social networks or functional activities in the brain. The representation, analysis and compression of such data is a challenging task and requires the development of new tools that can identify and adequately exploit the structure of the data.

In this course, students will become familiar with the framework of "Graph Signal Processing", a discipline useful for processing data lying on a graph and that extends basic concepts of signal processing to graphs, such as frequency domain and filtering. Hand-out sessions will provide students with practical skills in the analysis of data in graphs.



## STUDY LOAD

Type	Hours	Percentage
Hours small group	8,0	10.67
Self study	51,0	68.00
Hours large group	16,0	21.33

**Total learning time:** 75 h

## CONTENTS

### Introduction

**Description:**

Course organization. Motivation and applications of graph signals.

**Full-or-part-time:** 0h 30m

Theory classes: 0h 30m

### Algebraic graph theory

**Description:**

Graph theory fundamentals. Laplacian matrix and spectral properties.

**Related activities:**

Application: Random Walks on Graphs and Spectral Clustering

Practical Session: Spectral Clustering

**Full-or-part-time:** 14h 30m

Theory classes: 5h 30m

Practical classes: 3h

Self study : 6h

### Graph Signals

**Description:**

Definition of graph signals. Graph Fourier Transform. Convolution of graph signals.

**Related activities:**

Application: "Average Consensus"

Practical session: Frequency domain in graphs.

**Full-or-part-time:** 6h

Theory classes: 2h

Practical classes: 1h

Self study : 3h



### Graph topology learning

**Description:**

Graphs based on similarity of node attributes. Graph learning based on signals

**Full-or-part-time:** 6h

Theory classes: 2h

Practical classes: 1h

Self study : 3h

### Graph Convolutional Neural Networks

**Description:**

Multilayer Graph Convolutional Neural Networks with multiple features.

**Full-or-part-time:** 6h

Theory classes: 3h

Self study : 3h

### Graph Systems and Filtering of Graph Signals

**Description:**

Graph linear systems filters. Graph filters in the frequency domain. Examples of graph filters.

**Related activities:**

Application: Denoising of graph signals and translation of signals across a graph.

Practical session: filtering of graph signals.

**Full-or-part-time:** 7h

Theory classes: 4h

Practical classes: 1h

Self study : 2h

## GRADING SYSTEM

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- Attendance is mandatory.
- Participation in class.
- Individual assignments (~45%), and group or individual reports (~55%).

## EXAMINATION RULES.

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There is no final exam.

## BIBLIOGRAPHY

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**Basic:**

- Ortega, A. Introduction to graph signal processing. New York: Cambridge University Press, 2022. ISBN 9781108428132.

**Complementary:**

- Kolaczyk, Eric D. Statistical analysis of network data methods and models [on line]. New York: Springer, 2009 [Consultation: 08/06/2022]. Available on: <https://link-springer-com.recursos.biblioteca.upc.edu/book/10.1007/978-0-387-88146-1>. ISBN 9780387881454.
- Godsil, Chris; Royle, Gordon. Algebraic graph theory. New York: Springer, 2001. ISBN 9780387952413.



## RESOURCES

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### Computer material:

- Transparències de classe.. Lecture slides.
- Toolbox de grafs de Matlab i enunciats de sessions pràctiques.. Matlab graph toolbox and practical session guides.

### Other resources: