# Course guide
# 2707190 - UL - Unsupervised Learning

**Last modified:** 30/01/2026

**Unit in charge:** Barcelona School of Informatics
**Teaching unit:** 723 - CS - Department of Computer Science.

**Degree:** MASTER'S DEGREE IN ARTIFICIAL INTELLIGENCE (Syllabus 2017). (Optional subject).

**Academic year:** 2025 **ECTS Credits:** 4.5 **Languages:** English

## LECTURER

**Coordinating lecturer:**

**Others:** Segon quadrimestre:
JAVIER BÉJAR ALONSO - 10

## PRIOR SKILLS

Basic knowledge of clustering and neural networks

## DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

**Specific:**
CEA12. Capability to understand the advanced techniques of Knowledge Engineering, Machine Learning and Decision Support Systems, and to know how to design, implement and apply these techniques in the development of intelligent applications, services or systems.
CEA13. Capability to understand advanced techniques of Modeling , Reasoning and Problem Solving, and to know how to design, implement and apply these techniques in the development of intelligent applications, services or systems.
CEP1. Capability to solve the analysis of information needs from different organizations, identifying the uncertainty and variability sources.

**Generical:**
CG1. Capability to plan, design and implement products, processes, services and facilities in all areas of Artificial Intelligence.
CG3. Capacity for modeling, calculation, simulation, development and implementation in technology and company engineering centers, particularly in research, development and innovation in all areas related to Artificial Intelligence.

**Transversal:**
CT2. SUSTAINABILITY AND SOCIAL COMMITMENT: Being aware of and understanding the complexity of the economic and social phenomena typical of a welfare society, and being able to relate social welfare to globalisation and sustainability and to use technique, technology, economics and sustainability in a balanced and compatible manner.

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.

**Basic:**
CB7. Ability to integrate knowledges and handle the complexity of making judgments based on information which, being incomplete or limited, includes considerations on social and ethical responsibilities linked to the application of their knowledge and judgments.

## TEACHING METHODOLOGY

Presentation classes and class laboratories

## LEARNING OBJECTIVES OF THE SUBJECT

1.To known and use advanced unsupervised machine learning techniques for application on all the domains of engineering and science

## STUDY LOAD

| Type | Hours | Percentage |
|---|---|---|
| Self study | 72,0 | 64.00 |
| Hours large group | 40,5 | 36.00 |

**Total learning time:** 112.5 h

## CONTENTS

### Data Mining, a global perspective

**Description:**
Brief introduction to what is Data Mining and Knowledge Discovery, the areas they are related to and the different techniques involved

### Pre-processing and unsupervised data transformation

**Description:**
This topic will include different algorithms for unsupervised data preprocessing such as data normalization, discretization, outliers detection, dimensionality reduction and feature extraction (PCA, ICA, SVD, linear and non linear multidimensional scalling and non negative matrix factorization)

### Unsupervised Machine Learning

**Description:**
This topic will include classical and current algorithms for unsupervised learning from machine learning and statistics including hierarchical and parititional algorithms (K-means,Fuzzy C-means, Gaussian EM, graph partitioning, density based algorithms, grid based algorithms, unsupervised ANN, affinity propagation, ...)

### Unsupervised methodologies in Knowledge Discovery and Data Mining

**Description:**
This topic will include current trends on knowledge discovery for data mining and big data, (scalability, any time clustering, one pass algorithms, approximation algorithms, distributed clustering, ..)

### Advanced topics in unsupervised learning

**Description:**
This topic will include and introduction to different advanced topics in unsupervised learning such as consensus clustering, subspace clustering, biclustering and semisupervised clustering

**Unsupervised learning for sequential and structured data**

**Description:**
This topic will include algorithms for unsupervised learning with sequential data and structured data, such as sequences, strings, time series and data streams, graphs and social networks

**Unsupervised Deep Learning: Autoregressive and Flow models**

**Description:**
We will see algorithms able to estimate probability distribution models from unsupervised data that can be sampled to generate new data assuming autoregressive dependencies and flow transference models

**Unsupervised Deep Learning: Latent Variable models, Autoencoders and Variational Autoencoders**

**Description:**
This topic will introduce to latent variable models for learning of probabilistic models of data and latent representations for sampling and generating data for applications in image and text generation

**Unsupervised Deep Learning: Implicit models, Generative Adversarial Networks**

**Description:**
This topic will introduce to models that represent implicitly probability distribution models using adversarial learning. Different models based on Generative Adversarial Networks will be explained following its evolution since their original formulation. Different applications to image generation will be explained.

**Unsupervised Deep Learning: Diffusion Models**

**Description:**
This topic will introduce to generative models bases on latent variables that match a noise gaussian distribution with the data distribution using a discrete or continuous process in time simulating the physics of diffusion. We will see the formulation of these models as a stochastic or a deterministic process and its connection to differential equations

**Unsupervised Deep Learning: Self-supervised and Contrastive learning**

**Description:**
This topic will introduce to models for learning representations to be used for other tasks using self-supervised methodologies and contrastive learning. Different approaches for defining the unsupervised task used to learn a representation will be explained in the context of applications for image and text.

## ACTIVITIES

### Unsupervised learning

**Description:**
This activity develops the topics of the unsupervised learning part of the course

**Specific objectives:**
1

**Related competencies :**
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CB7. Ability to integrate knowledges and handle the complexity of making judgments based on information which, being incomplete or limited, includes considerations on social and ethical responsibilities linked to the application of their knowledge and judgments.

**Full-or-part-time:** 56h
Theory classes: 20h
Self study: 36h

**Unsupervised Deep Learning**

**Description:**
This activity develops the syllabus of the Unsupervised Deep learning part of the course

**Specific objectives:**
1

**Related competencies :**
CG1. Capability to plan, design and implement products, processes, services and facilities in all areas of Artificial Intelligence.
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**Full-or-part-time:** 56h 30m
Theory classes: 20h 30m
Self study: 36h

## GRADING SYSTEM

The evaluation will be based on final test exam about the topics of the course (20%), the implementation of an usupervised learning algorithm from a paper (40%) and a review and video presentation of a deep unsupervised learning paper (40%)

## RESOURCES

**Hyperlink:**
- https://sites.google.com/upc.edu/mai-ul