# Course guide
# 295119 - 295II234 - Plant Monitoring and Fault Detection

**Last modified:** 02/10/2025

**Unit in charge:** Barcelona East School of Engineering
**Teaching unit:** 749 - MAT - Department of Mathematics.
707 - ESAII - Department of Automatic Control.

**Degree:** MASTER'S DEGREE IN INTERDISCIPLINARY AND INNOVATIVE ENGINEERING (Syllabus 2019). (Optional subject).
ERASMUS MUNDUS MASTER IN SUSTAINABLE SYSTEMS ENGINEERING (EMSSE) (Syllabus 2024). (Optional subject).

**Academic year:** 2025 **ECTS Credits:** 6.0 **Languages:** English

## LECTURER

**Coordinating lecturer:** LUIS EDUARDO MUJICA DELGADO - FRANCESC POZO MONTERO

**Others:** Primer quadrimestre:
JOAQUIN BLESA IZQUIERDO - Grup: T1
LUIS EDUARDO MUJICA DELGADO - Grup: T1
MAGDA LILIANA RUIZ ORDOÑEZ - Grup: T1
YOLANDA VIDAL SEGUI - Grup: T1

## PRIOR SKILLS

It is assumed that the student has the fundamental concepts of calculus, algebra, systems theory of differential equations, and statistics acquired in the degree that allows access to the Master.

## REQUIREMENTS

There is not

## DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

**Specific:**
CEMUEII-16. Design monitoring systems, planning and control of automated industrial processes that allow automated predictive maintenance by detecting and diagnosing plant failures. (Specific competence of the Advanced Manufacturing Systems specialty)

**Generical:**
CGMUEII-01. Participate in technological innovation projects in multidisciplinary problems, applying mathematical, analytical, scientific, instrumental, technological and management knowledge.
CGMUEII-05. To communicate hypotheses, procedures and results to specialized and non-specialized audiences in a clear and unambiguous way, both orally and through reports and diagrams, in the context of the development of technical solutions for problems of an interdisciplinary nature.

**Transversal:**
05 TEQ. TEAMWORK. Being able to work as a team player, either as a member or as a leader. Contributing to projects pragmatically and responsibly, by reaching commitments in accordance to the resources that are available.
06 URI. EFFECTIVE USE OF INFORMATION RESOURCES. Managing the acquisition, structure, analysis and display of information from the own field of specialization. Taking a critical stance with regard to the results obtained.
03 TLG. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.

## LEARNING RESULTS

**Knowledges:**
K07. Design monitoring systems for complex industrial processes that enable automated predictive maintenance through plant fault detection and diagnosis.
K01. Design and implement modelling techniques to describe the behaviour of a system. Predict the stability of the system and apply control techniques in different scenarios.

**Skills:**
S01. Communicate effectively in oral, written and graphic form with others regarding learning, the development of ideas and decision making, and participate in discussions using interpersonal skills such as active listening and empathy, which foster teamwork.
S05. Apply pattern recognition, artificial intelligence and statistical data analysis techniques to make objective, quantitative and reproducible decisions in multidisciplinary problems.

**Competences:**
C03. Manage the acquisition, organisation, analysis and presentation of data and information in the field of complex systems engineering and critically assess the results obtained.
C05. Propose advanced scientific and technological solutions to complex industrial challenges in areas such as intelligent production, robotic systems, logistics, fault detection and predictive maintenance.
C02. Work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

## TEACHING METHODOLOGY

The development of class sessions follows a combined methodology. On one hand, a methodology close to the master classes will be applied, where the teaching staff will present the fundamental concepts of the subject. It is combined with a methodology close to the classes of problems and practices, where the students will work on examples and problems in numerical simulation proposed by the professor to reinforce and deepen the methodologies previously taught. Finally, there will be a session where the student can attend the laboratory to have contact with the available experiments.

## LEARNING OBJECTIVES OF THE SUBJECT

This course introduces the student in the field of detection and diagnosis of faults in processes, industrial systems and structures, as well as the supervision of them, making special use of data-based techniques (statistical methods) and models (analytical redundancy).

The student who has taken the course must be able to:
- Design and implement fault detection systems for processes, industrial systems and structures.
- Design and implement fault diagnosis systems for processes, industrial systems and structures.

Specific competences:
-The student should know the difference and similarities between data-based and model-based methods.
-The student must know the methods based on data that are applied for the detection of faults using statistical tools.
-The student must know the methods based on models that are applied for detection, isolation and fault estimation with analytical redundancy.
-The student must know the methods based on data that are applied to detect and diagnose defects or damages on structures.

## STUDY LOAD

| Type | Hours | Percentage |
|---|---|---|
| Self study | 108,0 | 72.00 |
| Hours large group | 21,0 | 14.00 |
| Hours small group | 21,0 | 14.00 |

**Total learning time:** 150 h

## CONTENTS

### Introduction to the monitoring of processes and decisions

**Description:**
Decision support systems
Operator training systems
Performance criteria

**Full-or-part-time:** 5h
Theory classes: 2h
Self study : 3h

### Data management

**Description:**
Data cleaning and filtering.
Pre-processing
Reduction of dimensionality.
Extraction of features.
Review of the most common strategies (PCA, SVD, etc.)

**Related activities:**
Activity 1: Computer lab session: Application in wind power generation systems

**Full-or-part-time:** 17h
Theory classes: 4h
Laboratory classes: 2h
Self study : 11h

### Statistical process monitoring

**Description:**
Univariable process monitoring.
Multivariable process monitoring
Multivariable Statistical methods for projection
Continuous processes
Batch processes

**Specific objectives:**
Activity 2: Computer lab sessions:
- Application in the detection of faults in electrical energy transmission.
- Application in the detection of faults in wastewater treatment plants.

**Full-or-part-time:** 26h
Theory classes: 4h
Laboratory classes: 4h
Self study : 18h

## Data-based fault diagnosis

**Description:**
Condition indicators
Classifiers as a decision model
Binary (healthy versus faulty)
Multiclass (diagnose among different type of faults)
Application to wind turbines

**Related activities:**
Activity 3: Computer lab sessions: Application in the detection of failures in wind turbines

**Full-or-part-time:** 26h
Theory classes: 4h
Laboratory classes: 4h
Self study : 18h

## Structural Health Monitoring

**Description:**
Introduction to Structural Health Monitoring (SHM)
Pattern recognition as SHM paradigm
Methods based on vibration and guided waves
Practical cases

**Related activities:**
Activity 4: Computer and experimental lab sessions: Application of Structural Health Monitoring on diverse kind of structures

**Full-or-part-time:** 29h
Theory classes: 2h
Laboratory classes: 6h
Self study : 21h

## Fault detection based on models

**Description:**
Introduction to fault detection based on models.
Fault detection methods based on models: parity equations, observers and parameter estimation.

**Related activities:**
Activity 5: Computer and lab sessions: Application in the detection of faults in wind turbines and drinking water distribution networks.

**Full-or-part-time:** 23h 30m
Theory classes: 3h
Laboratory classes: 3h
Guided activities: 2h
Self study : 15h 30m

**Fault diagnosis based on models**

**Description:**
Model-based fault diagnostics methods: Structural analysis, directional residual and parameter estimation.

**Full-or-part-time:** 23h 30m
Theory classes: 3h
Laboratory classes: 3h
Guided activities: 2h
Self study : 15h 30m

## GRADING SYSTEM

Projects and exercises 100% (10% chapter 1, 10% chapter 2, 20% chapter 3, 20% chapter 4, 20% chapter 5).

## BIBLIOGRAPHY

**Basic:**
- Isermann, Rolf. Fault-diagnosis systems : an introduction from fault detection to fault tolerance [on line]. Berlin [etc.]: Springer, cop. 2006 [Consultation: 14/04/2020]. Available on: http://dx.doi.org/10.1007/3-540-30368-5. ISBN 9783540303688.
- Farrar, Charles R; Worden, Keith. Structural health monitoring : a machine learning perspective. West Sussex: John Wiley & Sons Ltd, 2013. ISBN 9781119994336.
- Tibaduiza Burgos, Diego Alexander; Mujica, Luis Eduardo; Rodellar, Jose [eds.]. Emerging design solutions in structural health monitoring systems. Hershey: Engineering science reference, cop. 2015. ISBN 9781466684904.
- Russell, Evan L., Chiang, Leo H., Braatz, Richard D. Data-driven methods for fault detection and diagnosis in chemical processes. London: Springer-Verlag, 2000. ISBN 9781447104094.
- Jolliffe, I. T. Principal component analysis [on line]. 2n ed. New York: Springer, 2002 [Consultation: 14/04/2020]. Available on: https://link.springer.com/book/10.1007/b98835.
- Peña, Daniel. Análisis de datos multivariantes [on line]. Madrid: McGraw-Hill/Interamericana de España, [2013] [Consultation: 14/04/2020]. Available on: http://www.ingebook.com/ib/NPcd/IB_BooksVis?cod_primaria=1000187&codigo_libro=4203. ISBN 9788448136109.