ANX-PR/CL/001-01

LEARNING GUIDE

SUBJECT

43000554 - Experimental Structural Analysis

DEGREE PROGRAMME

04AI - Doble Master Universitario En Iccp Y En Sistemas De Ingenieria Civil

ACADEMIC YEAR & SEMESTER

2025/26 - Semester 1

Index

Learning guide

1. Description

1.1. Subject details

Name of the subject	43000554 - Experimental Structural Analysis
No of credits	4.5 ECTS
Type	Optional/elective
Academic year ot the programme	Second year
Semester of tuition	Semester 3
Tuition period	September-January
Tuition languages	English
Degree programme	04AI - Doble Master Universitario en Iccp y en Sistemas de Ingenieria Civil
Centre	04 - E.T.S. De Ing. De Caminos Canales Y P.
Academic year	2025-26

2. Faculty

2.1. Faculty members with subject teaching role

Name and surname	Office/Room	Email	Tutoring hours *
Carlos Martin De La Concha Renedo	Lab. Structures	carlos.martindelaconcha@upm.es	Tu - 11:00 - 12:00 Th - 11:00 - 12:00
Antonio Jose Madrid Ramos	Lab. Structures	antoniojose.madrid@upm.es	Th - 10:30 - 13:30 F - 16:00 - 19:00
Ivan Muñoz Diaz	Lab. Structures	ivan.munoz@upm.es	W - 11:00 - 14:00 Th - 11:00 - 14:00

Carlos Zanuy Sanchez (Subject coordinator)	Lab. Structures	carlos.zanuy@upm.es	Th - 11:00 - 14:00 F - 11:00 - 14:00
Jose Manuel Soria Herrera	9th Floor	jm.soria@upm.es	Tu - 12:00 - 14:00 W - 12:00 - 14:00 Th - 12:00 - 14:00
Gonzalo Sanz-Diez De Ulzurrun Casals	Lab. Structures	g.ulzurrun@upm.es	Th - 11:00 - 16:00

* The tutoring schedule is indicative and subject to possible changes. Please check tutoring times with the faculty member in charge.

3. Prior knowledge recommended to take the subject

3.1. Recommended (passed) subjects

- Elasticidad Aplicada

3.2. Other recommended learning outcomes

The subject - other recommended learning outcomes, are not defined.

4. Skills and learning outcomes *

4.1. Skills to be learned

MICCPCE38 - Capacidad para integrar y aplicar los conocimientos técnicos en asesoría, análisis, diseño y modelización físico-matemática en ingeniería estructural. Incorpora las competencias CB6, CB7 y CB8

MICCPCGP11 - Capacidad para el proyecto, ejecución e inspección de estructuras (puentes, edificaciones, etc.), de obras de cimentación y de obras subterráneas de uso civil (túneles, aparcamientos), y el diagnóstico sobre su integridad. Incorpora las competencias CB6, CB7 y CB8.

MICCPCT01 - Capacidad de preparar y presentar comunicaciones orales, escritas y gráficas, estructurada y argumentadamente. Desarrolla la competencia CB9.

MICCPCT03 - Capacidad de comunicación técnica oral y escrita en lengua inglesa. Desarrolla la competencia transversal 1ª de la normativa UPM.

MICCPCT08 - Capacidad de diseñar, analizar e interpretar experimentos relevantes en ingeniería civil.

4.2. Learning outcomes

RA121 - SO1 The student knows the fundamentals and applications of the most relevant transducers for instrumentation of structures.

RA122 - The student acquires the fundamentals of static and dynamic experimental techniques in structural engineering, and understands the structural implications of taken measurements.

* The Learning Guides should reflect the Skills and Learning Outcomes in the same way as indicated in the Degree Verification Memory. For this reason, they have not been translated into English and appear in Spanish.

5. Brief description of the subject and syllabus

5.1. Brief description of the subject

This course deals with the fundamentals and applications of experimental techniques in structural engineering. This course is divided into three parts: the first part is aimed at the study of instrumentaion techniques and equipment; the second part deals with the design of load tests in bridges and buildings; the goal of the last part is the study of dynamic testing techniques.

5.2. Syllabus

1. Introduction to instrumentation
    1.1. Definitions
    1.2. Transducers. Types of transducers
    1.3. Characteristics of transducers
2. Signal conditioning
    2.1. Basics of Electrotechnics. Background
    2.2. Electric circuits in signal conditioning
    2.3. Signal amplification
3. Strain measurement
    3.1. Working principle of strain gages

3.2. Configuration of strain gages

3.3. Characteristics of strain gages

3.4. Conditioning circuits for strain gages

4. Load measurement

4.1. Load cells

4.2. Equipment for load application

5. Displacement measurement

5.1. Potentiometers

5.2. Inductive transducers. LVDT

5.3. Rotation measurement

6. Acceleration measurement

6.1. Dynamic measurements

6.2. Accelerometers. Definition and types

7. Load tests in bridges

7.1. Fundamentals and methodology

7.2. Codes and standards

8. Load tests in buildings

8.1. Fundamentals and methodology

8.2. Codes and standards

9. Frequency domain analysis

9.1. Fourier analysis

9.2. Single-degree-of-freedom systems

9.3. Multiple degree-of-freedom systems

9.4. Analysis of discrete signals

10. Equipment for dynamic analysis

10.1. Key characteristics of equipment for dynamic measurements

10.2. Types of excitation

10.3. Transducers

10.4. Data acquisition systems

11. In-service condition monitoring

    11.1. Analysis of measurements taken under in-service conditions

    11.2. In-service monitoring

12. Modal analysis

    12.1. Theoretical analysis vs. Experimental analysis

    12.2. Estimation of frequency response functions

    12.3. Estimation of modal parameters

    12.4. Operational modal analysis

6. Schedule

6.1. Subject schedule*

Week	Type 1 activities	Type 2 activities	Distant / On-line	Assessment activities
1	**Unit 1** Duration: 03:00 Lecture			
2	**Unit 2** Duration: 02:00 Lecture **Unit 2** Duration: 01:00 Problem-solving class			
3	**Unit 3** Duration: 02:00 Lecture **Unit 3** Duration: 01:00 Problem-solving class			
4	**Unit 4** Duration: 01:00 Lecture **Units 3-4** Duration: 00:30 Problem-solving class	**Units 1-3** Duration: 01:30 Laboratory assignments		**Resolution and submission of assigned tasks (exercises and case-studies) during the course. The assignments will mainly include practical exercises based on the lectures and laboratory classes.** Individual work Progressive assessment Not Presential Duration: 03:00
5	**Unit 5** Duration: 01:00 Lecture **Units 4-5** Duration: 00:30 Problem-solving class	**Units 1-3** Duration: 01:30 Laboratory assignments		**Resolution and submission of assigned tasks (exercises and case-studies) during the course. The assignments will mainly include practical exercises based on the lectures and laboratory classes.** Individual work Progressive assessment Not Presential Duration: 03:00
6	**Unit 6** Duration: 01:00 Lecture	**Units 4-5** Duration: 02:00 Laboratory assignments		**Resolution and submission of assigned tasks (exercises and case-studies) during the course. The assignments will mainly include practical exercises based on the lectures and laboratory classes.** Individual work Progressive assessment Not Presential Duration: 03:00

7	**Unit 7** Duration: 02:00 Lecture **Unit 7** Duration: 01:00 Problem-solving class			
8	**Unit 8** Duration: 02:00 Lecture **Unit 8** Duration: 01:00 Problem-solving class			**Resolution and submission of assigned tasks (exercises and case-studies) during the course. The assignments will mainly include practical exercises based on the lectures and laboratory classes.** Individual work Progressive assessment Not Presential Duration: 03:00
9	**Unit 9** Duration: 02:00 Lecture **Unit 9** Duration: 01:00 Problem-solving class			
10	**Unit 9** Duration: 02:00 Lecture **Unit 9** Duration: 01:00 Problem-solving class			
11	**Unit 10** Duration: 02:00 Lecture **Unit 10** Duration: 01:00 Problem-solving class			
12	**Unit 10** Duration: 02:00 Lecture **Unit 10** Duration: 01:00 Problem-solving class			
13	**Unit 11** Duration: 01:00 Lecture **Unit 11** Duration: 00:30 Problem-solving class	**Units 10-11** Duration: 01:30 Laboratory assignments		**Resolution and submission of assigned tasks (exercises and case-studies) during the course. The assignments will mainly include practical exercises based on the lectures and laboratory classes.** Individual work Progressive assessment Not Presential Duration: 03:00
14	**Unit 12** Duration: 01:00 Lecture **Unit 12** Duration: 01:00 Problem-solving class	**Unit 12** Duration: 01:00 Laboratory assignments		**Resolution and submission of assigned tasks (exercises and case-studies) during the course. The assignments will mainly include practical exercises based on the lectures and laboratory classes.** Individual work Progressive assessment Not Presential

				Duration: 03:00
15	**Unit 12** Duration: 01:00 Lecture **Unit 12** Duration: 02:00 Problem-solving class			**Resolution and submission of assigned tasks (exercises and case-studies) during the course. The assignments will mainly include practical exercises based on the lectures and laboratory classes.** Individual work Progressive assessment Not Presential Duration: 03:00
16	**Units 9-12** Duration: 01:00 Problem-solving class	**Unit 12** Duration: 02:00 Laboratory assignments		
17	**Oral presentations** Duration: 03:00 Problem-solving class			**Final exam** Written test Global examination Presential Duration: 03:00 **Final exam** Written test Progressive assessment Presential Duration: 03:00

Depending on the programme study plan, total values will be calculated according to the ECTS credit unit as 26/27 hours of student face-to-face contact and independent study time.

7. Activities and assessment criteria

7.1. Assessment activities

7.1.1. Assessment

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
4	Resolution and submission of assigned tasks (exercises and case-studies) during the course. The assignments will mainly include practical exercises based on the lectures and laboratory classes.	Individual work	No Presential	03:00	5.7%	3.5 / 10	MICCPCGP11 MICCPCT01 MICCPCT03 MICCPCT08 MICCPCE38
5	Resolution and submission of assigned tasks (exercises and case-studies) during the course. The assignments will mainly include practical exercises based on the lectures and laboratory classes.	Individual work	No Presential	03:00	5.7%	3.5 / 10	MICCPCGP11 MICCPCT01 MICCPCT03 MICCPCT08 MICCPCE38
6	Resolution and submission of assigned tasks (exercises and case-studies) during the course. The assignments will mainly include practical exercises based on the lectures and laboratory classes.	Individual work	No Presential	03:00	5.7%	3.5 / 10	MICCPCGP11 MICCPCT01 MICCPCT03 MICCPCT08 MICCPCE38
8	Resolution and submission of assigned tasks (exercises and case-studies) during the course. The assignments will mainly include practical exercises based on the lectures and laboratory classes.	Individual work	No Presential	03:00	5.7%	3.5 / 10	MICCPCGP11 MICCPCT01 MICCPCT03 MICCPCT08 MICCPCE38
13	Resolution and submission of assigned tasks (exercises and case-studies) during the course. The assignments will mainly include practical exercises based on the lectures and laboratory classes.	Individual work	No Presential	03:00	5.7%	3.5 / 10	MICCPCGP11 MICCPCT01 MICCPCT03 MICCPCT08 MICCPCE38
14	Resolution and submission of assigned tasks (exercises and case-studies) during the course. The assignments will mainly include practical exercises based on the lectures and laboratory classes.	Individual work	No Presential	03:00	5.7%	3.5 / 10	MICCPCGP11 MICCPCT01 MICCPCT03 MICCPCT08 MICCPCE38

15	Resolution and submission of assigned tasks (exercises and case-studies) during the course. The assignments will mainly include practical exercises based on the lectures and laboratory classes.	Individual work	No Presential	03:00	5.7%	3.5 / 10	MICCPCGP11 MICCPCT01 MICCPCT03 MICCPCT08 MICCPCE38
17	Final exam	Written test	Face-to-face	03:00	60.1%	3.5 / 10	MICCPCGP11 MICCPCT01 MICCPCT03 MICCPCT08 MICCPCE38

7.1.2. Global examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
17	Final exam	Written test	Face-to-face	03:00	100%	5 / 10	MICCPCGP11 MICCPCT01 MICCPCT03 MICCPCT08 MICCPCE38

7.1.3. Referred (re-sit) examination

Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
Final exam	Written test	Face-to-face	03:00	100%	5 / 10	MICCPCGP11 MICCPCT01 MICCPCT03 MICCPCT08 MICCPCE38

7.2. Assessment criteria

Evaluation through "continuous assessment"

EM1. Students' work 40%

Description: Resolution and submission of assigned tasks (exercises and case-studies) during the course. Necessary material for the tasks will be found on the Moodle platform and the laboratory classes. The assignments will mainly include practical exercises based on the lectures and laboratory classes.

Evaluation criteria: The assignments will be ranked from 0 to 10 as a result of the weighted average of the results obtained in the exercises and case-studies. Weights will be according to the difficulty and work required by the exercises.

Place and period: The submission system will be available on the Moodle platform. The exercises and case-studies shall be completed according to the schedule and conditions announced during the course. The required knowledge will be explained in the lectures and laboratory classes.

EM2. Final exam 60%

Description: The final exam will consist of two parts, with duration of 1-1.5 hours each. The first part will consist of applied theory. The second part will consist of two practical exercises.

Evaluation criteria: The final exam will be ranked from 0 to 10. The weight of each part can be around 40-60%.

Place and period: To be determined by the Head of Studies

Result of the evaluation through "continuous assessment"

The final score will be the weighted average of the results obtained in EM1 and EM2 according to the indicated weights. It is required at least 3.5 points at each part to pass the subject by continuous assessment.

The subject will be passed if the final score is equal or greater than 5.

Those students with a score less than 5 will not pass the subject and will have another opportunity in the second period examination (extraordinary).

Evaluation through "final exam only"

Description: The exam will be the same final exam done by the students under the evaluation through "continuous assessment" (EM2).

Evaluation criteria: The same as the one indicated above for the final exam EM2, thereby resulting in a score from 0 to 10.

Place and period: To be determined by the Head of Studies.

Result of the evaluation through "final exam only"

The final score will be the one obtained in the final exam.

The subject will be passed if the final score is equal or greater than 5.

Those students with a score less than 5 will not pass the subject and will have another opportunity in the second examination period (extraordinary).

8. Teaching resources

8.1. Teaching resources for the subject

Name	Type	Notes
Moodle platform	Web resource	Lectures' presentations; Assignments for students; Recommended references.
Instrumentación aplicada a la ingeniería	Bibliography	Fraile Mora J., García Gutiérrez P., Fraile Ardanuy J. (2012). Instrumentación aplicada a la ingeniería. Editorial Garceta, Madrid.
Modal Testing: theory, practice and Application	Bibliography	Ewins D. J. (2000). Modal Testing: theory, practice and Application. Editorial Research Studies Press, Baldock, Hertfordshire, Reino Unido
Análisis experimental de estructuras	Bibliography	Blanco, Díaz E., Oller Martínez, S. y Gil Espert, L. (2008). Análisis experimental de estructuras. Editorial: Centro Internacional de Métodos Numéricos en Ingeniería, Barcelona, España
Laboratory of Structures	Equipment	Equipment and materials for laboratory classes
Library of the School	Equipment	Handbooks and technical literature