



POLITÉCNICA

INTERNATIONAL  
CAMPUS OF  
EXCELLENCE

COORDINATION PROCESS OF  
LEARNING ACTIVITIES  
PR/CL/001



E.T.S. de Ing. de Caminos  
Canales y P.

# ANX-PR/CL/001-01

## LEARNING GUIDE

### SUBJECT

**43000546 - Design, Analysis And Construction Of Bridges**

### DEGREE PROGRAMME

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

### ACADEMIC YEAR & SEMESTER

2025/26 - Semester 2

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## 1. Description

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### 1.1. Subject details

<b>Name of the subject</b>	43000546 - Design, Analysis And Construction Of Bridges
<b>No of credits</b>	4.5 ECTS
<b>Type</b>	Optional/elective
<b>Academic year of the programme</b>	Second year
<b>Semester of tuition</b>	Semester 4
<b>Tuition period</b>	February-June
<b>Tuition languages</b>	English
<b>Degree programme</b>	04AI - Doble Master Universitario en Iccp y en Sistemas de Ingeniería Civil
<b>Centre</b>	04 - E.T.S. De Ing. De Caminos Canales Y P.
<b>Academic year</b>	2025-26

## 2. Faculty

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### 2.1. Faculty members with subject teaching role

<b>Name and surname</b>	<b>Office/Room</b>	<b>Email</b>	<b>Tutoring hours *</b>
Alfredo Camara Casado	9ª Torre	alfredo.camara@upm.es	W - 16:00 - 19:00
Jose Manuel Simon-Talero Muñoz	Torre 9º	jm.simon-talero@upm.es	M - 14:00 - 16:00 W - 14:00 - 16:00
Antonio Aureo Martinez Cutillas (Subject coordinator)	Torre 9º	a.martinez.cutillas@upm.es	Sin horario.

\* 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

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#### 3.1. Recommended (passed) subjects

- Morfología De Puentes

#### 3.2. Other recommended learning outcomes

- Tipología estructural

### 4. Skills and learning outcomes \*

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#### 4.1. Skills to be learned

MICCPCE32 - Capacidad para aplicar los conocimientos técnicos en la evaluación de proyectos, obras e infraestructuras dentro del ámbito de la ingeniería civil.

MICCPCE33 - Capacidad para aplicar los conocimientos técnicos en actividades de I+D+i dentro del ámbito de la ingeniería civil. Incorpora las competencias CB6, CB7 y CB8.

MICCPCE34 - Capacidad para integrar y aplicar los conocimientos técnicos en asesoría, análisis, cálculo, proyecto, construcción, y evaluación técnica de infraestructuras de ingeniería civil. Incorpora las competencias CB6, CB7 y CB8.

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

MICCPCE39 - Capacidad predictiva para optimización de soluciones en ingeniería estructural. Incorpora las competencias CB6, CB7 y CB8.

MICCCPGP01 - Capacitación científico-técnica y metodológica para el reciclaje continuo de conocimientos y el ejercicio de las funciones profesionales de asesoría, análisis, diseño, cálculo, proyecto, planificación, dirección, gestión, construcción, mantenimiento, conservación y explotación en los campos de la ingeniería civil. Incorpora las competencias CB6, CB7 y CB8

MICCCPGP02 - alternativas válidas, elegir la óptima y plasmarla adecuadamente, previendo los problemas de su construcción, y empleando los métodos y tecnologías más adecuadas, tanto tradicionales como innovadores, con la finalidad de conseguir la mayor eficacia y favorecer el progreso y un desarrollo de la sociedad sostenible y respetuoso con el medio ambiente. Incorpora las competencias CB6, CB7 y CB8.

MICCCPGP03 - Conocimiento, comprensión y capacidad para aplicar la legislación necesaria en el ejercicio de la profesión de Ingeniero de Caminos, Canales y Puertos. Incorpora las competencias CB6, CB7 y CB8.

MICCCPGP04 - Conocimiento de la historia de la ingeniería civil y capacitación para analizar y valorar las obras públicas en particular y de la construcción en general. Incorpora las competencias CB6, CB7 y CB8.

MICCCPGP05 - Conocimiento de la profesión de Ingeniero de Caminos, Canales y Puertos y de las actividades que se pueden realizar en el ámbito de la ingeniería civil. Incorpora las competencias CB6, CB7 y CB8.

MICCCPGP06 - Conocimiento para aplicar las capacidades técnicas y gestoras en actividades de I+D+i dentro del ámbito de la ingeniería civil. Incorpora las competencias CB6, CB7 y CB8.

MICCCPGP07 - Capacidad para planificar, proyectar, inspeccionar y dirigir obras de infraestructuras de transportes terrestres (carreteras, ferrocarriles, puentes, túneles y vías urbanas) o marítimos (obras e instalaciones portuarias). Incorpora las competencias CB6, CB7 y CB8.

MICCCPGP11 - 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.

MICCCPGP12 - Capacidad para planificar, diseñar y gestionar infraestructuras, así como su mantenimiento, conservación y explotación. Incorpora las competencias CB6, CB7 y CB8.

MICCCPGP18 - Conocimientos adecuados de los aspectos científicos y tecnológicos de métodos matemáticos, analíticos y numéricos de la ingeniería, mecánica de fluidos, mecánica de medios continuos, cálculo de estructuras, ingeniería del terreno, ingeniería marítima, obras y aprovechamientos hidráulicos y obras lineales. 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.

MICCPCT02 - Polivalencia y capacidad de aprendizaje autónomo. Desarrolla la competencia CB10.

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

MICCPCT04 - Capacidad de organizar y dirigir los esfuerzos de un equipo. Desarrolla la competencia transversal 5ª de la normativa UPM.

MICCPCT05 - Capacidad de ejercer las funciones profesionales de proyecto, cálculo, evaluación técnica, planificación y gestión técnica mediante el uso de normativa europea e internacional. Desarrolla la competencia transversal 7ª de la normativa UPM.

MICCPCT06 - Compromiso y capacidad de aplicación de los estándares de deontología profesional.

MICCPCT07 - Capacidad de utilización de los servicios de información y comunicación para el ejercicio de las funciones profesionales del perfil de egreso. Desarrolla la competencia transversal 3ª de la normativa UPM

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

## 4.2. Learning outcomes

RA21 - Aplica y evalúa técnicas avanzadas para la construcción y control de obras de ingeniería estructural y geotécnica

RA20 - Aplica y evalúa modelos avanzados de ingeniería estructural y geotécnica en proyecto y ejecución de obras

RA22 - Aplica y evalúa modelos avanzados de comportamiento mecánico y medioambiental de suelos y materiales de construcción.

\* 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

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### 5.1. Brief description of the subject

The teacher will explain the concepts necessary to understand the concepts of the course in order for the student to achieve the expected indicators. The teacher will use appropriate practical examples and logical reasoning to develop the scientific and technical abilities of the student. The participation of students will be encouraged by means of discussions on the topics taught.

Practice lessons will be aimed at the resolution of exercises and case-studies. Practice lessons are intended as a correlation between the content of theory lessons and engineering practice, in order for the student to achieve the ability to apply the acquired knowledge in the future career. The teacher will first solve some exercises and case-studies to show the students how to work on their own later.

### 5.2. Syllabus

1. Introduction to non conventional, medium span or large span bridges
  - 1.1. Determinants that led to plan a non conventional bridge. Bridge typology. Examples.
2. The box girder bridge
  - 2.1. Transverse and longitudinal morphology. Resistant behaviour: longitudinal bending, cross bending, torsion, non uniform torsion, distortion
  - 2.2. application of numerical methods, bridge modelling.
  - 2.3. Construction: movable scaffolding system, launching girder, cantilever segmental construction, precast segments, incremental launching.
3. The skew bridge
  - 3.1. Morphology, supporting conditions, resistant behaviour, precast beams deck, slab deck, closed box deck. Modelling, prestressing. Applications.
4. The curved bridge
  - 4.1. Morphology, supporting conditions, resistant behaviour, precast beams deck, slab deck, closed box deck. Modelling, prestressing. Applications.
5. The portal frame bridge
  - 5.1. Morphology, supporting conditions, resistant behaviour depending on the ground and supporting

conditions, prestressing design, construction, applications.

## 6. The railroad bridge

6.1. Morphology. Special features of the hi-speed railroad bridges. Specific actions on railroad bridges.

6.2. Spanish and European regulation. Serviceability conditions. Location of expansion joints in the bridge and on the road. Introduction to dynamic effects.

## 7. Arch bridges

7.1. Morphology. Linkages. Resistant behaviour: deck bridge, through bridge, spandrel bridge, network bridge. Arch construction. Applications.

## 8. Cable-stayed bridges.

8.1. Longitudinal morphology. Transverse morphology. Towers. Cable properties. Cable-stayed bridge behaviour against vertical and horizontal actions.

8.2. Calculation of cable-stayed bridges. Definition of reference state. Modelling. Construction process: cantilever method, over provisional supports. Applications.

## 9. Extradosed bridges.

9.1. Longitudinal morphology. Transverse morphology. Towers. Cable properties. Extradosed bridge behaviour against vertical and horizontal actions.

9.2. Calculation of extradosed bridges. Definition of reference state. Construction process

## 10. Extraordinary actions.

10.1. Scouring: description, research, protection design. Ship collision: description, actions during the collision, calculation, protection against the ship collision.

## 11. Inspection and maintenance.

11.1. Bridge management. Periodic inspection policy. Maintenance programs. Bridge rehabilitation.

## 12. Integral and semi integral bridges.

12.1. Justification, morphology, design and analysis, applications.

## 6. Schedule

### 6.1. Subject schedule\*

Week	Type 1 activities	Type 2 activities	Distant / On-line	Assessment activities
1	<b>Unit 1</b> Duration: 03:45 Lecture			
2	<b>Unit 2</b> Duration: 02:30 Lecture		<b>Unit 2</b> Duration: 01:15 Problem-solving class	
3	<b>Unit 2</b> Duration: 02:30 Lecture		<b>Unit 2</b> Duration: 01:15 Problem-solving class	
4	<b>Unit 2</b> Duration: 02:30 Lecture		<b>Unit 2</b> Duration: 01:15 Problem-solving class	
5	<b>Unit 3</b> Duration: 02:30 Lecture		<b>Unit 3</b> Duration: 01:15 Problem-solving class	
6	<b>Unit 4</b> Duration: 02:30 Lecture		<b>Unit 4</b> Duration: 01:15 Problem-solving class	
7	<b>Unit 5</b> Duration: 02:30 Lecture		<b>Unit 5</b> Duration: 01:15 Problem-solving class	
8	<b>Unit 6</b> Duration: 02:30 Lecture		<b>Unit 6</b> Duration: 00:45 Problem-solving class	<b>Midterm exam: It consists of an exam formed by several questions of a theoretical nature, related to the subjects explained to date.</b> Written test Progressive assessment Presential Duration: 02:00
9				
10	<b>Unit 7</b> Duration: 02:30 Lecture		<b>Unit 7</b> Duration: 01:15 Problem-solving class	
11	<b>Unit 8</b> Duration: 02:30 Lecture		<b>Unit 8</b> Duration: 01:15 Problem-solving class	
12	<b>Unit 9</b> Duration: 02:30 Lecture		<b>Unit 9</b> Duration: 01:15 Problem-solving class	
13	<b>Unit 10</b> Duration: 02:30 Lecture		<b>Unit 10</b> Duration: 01:15 Problem-solving class	

14	<b>Unit 11</b> Duration: 02:30 Lecture		<b>Unit 11</b> Duration: 01:15 Problem-solving class	
15	<b>Unit 12</b> Duration: 02:30 Lecture		<b>Unit 12</b> Duration: 01:15 Problem-solving class	
16				<p><b>Final exam: The first part consists of several questions of a theoretical and practical nature, corresponding to the subjects of the subject not included in the partial exam. All students should examine themselves in this part.</b></p> <p>Written test Progressive assessment Presential Duration: 02:00</p> <p><b>Final Exam: The second part consists of several theoretical and practical questions corresponding to the topics related to the partial exam. They are not required to present themselves, only those who want to improve their grades. See evaluation criteria</b></p> <p>Written test Progressive assessment Presential Duration: 01:00</p> <p><b>Final Exam: It will be the same complete final exam that the continuous assessment students take</b></p> <p>Problem-solving test Global examination Presential Duration: 03:00</p>
17				

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
8	Midterm exam: It consists of an exam formed by several questions of a theoretical nature, related to the subjects explained to date.	Written test	Face-to-face	02:00	35%	5 / 10	MICCPGCP01 MICCPCT02 MICCPCT05 MICCPGCP02 MICCPGCP18 MICCPGCP11 MICCPGCP07 MICCPCT01 MICCPGCP05 MICCPGCP06 MICCPGCP04 MICCPCT08 MICCPCE38 MICCPGCP03 MICCPCT07 MICCPCE32 MICCPCE33 MICCPCE39 MICCPGCP12 MICCPCT06 MICCPCT04 MICCPCE34 MICCPCT03
16	Final exam: The first part consists of several questions of a theoretical and practical nature, corresponding to the subjects of the subject not included in the partial exam. All students should examine themselves in this part.	Written test	Face-to-face	02:00	65%	5 / 10	MICCPCT02 MICCPCT05 MICCPGCP02 MICCPGCP18 MICCPGCP11 MICCPGCP07 MICCPCT01 MICCPCT07 MICCPGCP05 MICCPGCP06 MICCPGCP04 MICCPCT08 MICCPCE38 MICCPGCP03 MICCPCE32 MICCPCE33 MICCPCE39



### 7.1.3. Referred (re-sit) examination

Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
Examen final	Written test	Face-to-face	02:00	100%	5 / 10	MICCPGCP01 MICCPCT02 MICCPCT05 MICCPGCP02 MICCPGCP18 MICCPGCP11 MICCPGCP07 MICCPCT01 MICCPCT07 MICCPGCP05 MICCPGCP06 MICCPGCP04 MICCPCT08 MICCPCE38 MICCPGCP03 MICCPCE32 MICCPCE33 MICCPCE39 MICCPGCP12 MICCPCT06 MICCPCT04 MICCPCE34 MICCPCT03

## 7.2. Assessment criteria

### Through continuous assessment

#### PE1. Partial exam 50%

Description: Consists of an exam that has several theoretical and practical questions, related to the units treated during the classes until the exam date. The approximate duration of the exam will be 2 hour.

Evaluation criteria: The exam will be ranked from 0 to 10 doing the arithmetic mean of the score of each exercise.

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

#### PE2. Final exam 50% or 100%

Description: It will consist of two parts, each of them will last 2 hours. The first one will have several theoretical and practical questions related to the lessons of the midterm exam. It is not obligatory for the students who have reached a score of 4 or higher in the midterm exam to be examined of this part although they can be examined if they want to reach a higher score. For the students who do the midterm exam and the first part of the final exam it will also be taken into account the best of the scores reached in the two exams.

The second part, which will have to be done by all the students, has several theoretical and practical questions, related to the units not included in the midterm exam. All the students have to do this part.

Evaluation criteria: Each exercise will be ranked from 0 to 10. The final score of the exam will be the arithmetic mean of the scores obtained in the exercises. For the students who do the two parts, the weight of the final exam will be the 100% and for those who only do the second part, it will be the 50%.

Place and period: To be determined by the Head of Studies. For organization reasons, first it will be done the second part of the subject (obligatory for all the students). Once this is done, the students who have to or want to do the first part of the subject will do the first part.

### Results of the evaluation through continuous assessment

The final score will be the highest of the following:

- For the students who pass the midterm exam: PE1 (50%) and PE2 (50%), provided that the PE1 and PE2 marks are not lower than 3.5.
- For the students who do the complete final exam: PE2 (100%), provided that the PE2 mark is not lower than 3.5.

The subject will be passed if the final score is equal or greater than 5 and both exams are not lower than 3.5.

Those students with a score less than 5 will not pass the subject and will have another opportunity in the second period examination (extraordinary) which will have the same format as the evaluation through final exam only.

### Evaluation through final exam only

Description: Consists of the same final exam as the one that will do the students who choose the continuous assessment evaluation.

Evaluation criteria: Each of the exercises will be ranked from 0 to 10 points. The final score will be the arithmetic mean of the scores obtained in each exercise provided that the marks obtained in the first and the second parts are not lower than 3.5.

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

## 8. Teaching resources

### 8.1. Teaching resources for the subject

Name	Type	Notes
Hewson N.R. (2003), Prestressed Concrete Bridges, Thomas Telford	Bibliography	Basic
Manterola J. (2006), Puentes: Apuntes para su Diseño, Cálculo y Construcción, Colegio de Ingenieros de Caminos, Canales y Puertos	Bibliography	Basic
Menn C.(1986), Prestressed Concrete Bridges, BirkHäuser Verlag	Bibliography	Basic
Walther R., Houriet B., Isler W., Moia P. & Klein J.F. (1999), Cable Stayed Bridges, Thomas Telford	Bibliography	Basic
Benaim R. (2008), The Design of Prestressed Concrete Bridges, Taylos & Francis	Bibliography	complementary
Calgaro J.A. (1988), Projet et Construction des Ponts: Analyse Structurale des Tabliers de Ponts, Presses de l'École Nationale des Ponts et Chaussées	Bibliography	complementary

Leonhardt F. (1982), Bridges, Deustche Verlags-Anstalt	Bibliography	complementary
Liebenberg A.C. (1992), Concrete Bridges: Design and Construction, Longman Scientific and Technical	Bibliography	complementary
Monleón S. (1997), Ingeniería de Puentes: Análisis Estructural, Universidad Politécnica de Valencia	Bibliography	complementary
Svensson H. (2012), Cable Stayed Bridges: 40 Years of Experience Worldwide, Wiley	Bibliography	complementary
Área virtual de la ETSICCP. Área virtual (MOODLE).	Web resource	
Biblioteca del departamento de Mecánica de Medios Continuos y Teoría de Estructuras.	Equipment	

## 9. Other information

### 9.1. Other information about the subject

#### Theory lessons:

The teacher will explain the concepts necessary to understand the concepts of the course in order for the student to achieve the expected indicators. The teacher will use appropriate practical examples and logical reasoning to develop the scientific and technical abilities of the student. The participation of students will be encouraged by means of discussions on the topics taught.

#### Practice lessons:

Practice lessons will be aimed at the resolution of exercises and case-studies. Practice lessons are intended as a correlation between the content of theory lessons and engineering practice, in order for the student to achieve the ability to apply the acquired knowledge in the future career. The teacher will first solve some exercises and case-studies to show the students how to work on their own later.

#### Laboratory classes:

No laboratory classes will be conducted on this subject

Independent work:

The student shall study the contents explained in theory lessons and shall strive to solve the exercises and case-studies.

Group work:

There are not any specific group works.

Office hours

Office hours are intended as a complement for the students to ask questions on the content of the course. Details of office hours are detailed at the beginning of this guide for each teacher.