

## Course guide

# 2500029 - GECINFTRAN - Transportation Infrastructures

Last modified: 01/10/2023

**Unit in charge:** Barcelona School of Civil Engineering  
**Teaching unit:** 751 - DECA - Department of Civil and Environmental Engineering.

**Degree:** BACHELOR'S DEGREE IN CIVIL ENGINEERING (Syllabus 2020). (Compulsory subject).

**Academic year:** 2023    **ECTS Credits:** 6.0    **Languages:** Spanish, English

### LECTURER

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**Coordinating lecturer:** ADRIANA HAYDEE MARTINEZ REGUERO

**Others:** ADRINA BACHILLER SAÑA, CARLES CASAS ESPLUGAS, EDUARDO FERNANDEZ DE VILLALTA FERRER-DALMAU, TERESA LÓPEZ MONTERO, ADRIANA HAYDEE MARTINEZ REGUERO

### DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

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#### Specific:

14413. Capacity for the construction and conservation of roads, as well as for the dimensioning, the project and the elements that make up the basic road equipment. (Specific technology module: Civil Construction)

14414. Capacity for the construction and conservation of railway lines with knowledge to apply specific technical regulations and differentiating the characteristics of the mobile material. (Specific technology module: Civil Construction)

14422. Capacity for the construction and conservation of roads, as well as for the dimensioning, the project and the elements that make up the basic road equipment. (Specific technology module: Urban Transport and Services)

14423. Capacity for the construction and conservation of railway lines with knowledge to apply specific technical regulations and differentiating the characteristics of the mobile material. (Specific technology module: Urban Transport and Services)

14426. Knowledge of the design and operation of infrastructures for modal exchange, such as ports, airports, railway stations and transport logistics centers. (Specific technology module: Urban Transport and Services)

#### Generical:

14380. Scientific-technical training for the exercise of the profession of Technical Engineer of Public Works and knowledge of the functions of advice, analysis, design, calculation, project, construction, maintenance, conservation and exploitation.

14383. Ability to project, inspect and direct works, in their field.

14385. Ability to carry out territorial planning studies and environmental aspects related to infrastructure, in its field.

14386. Capacity for maintenance, conservation and exploitation of infrastructure, in its field.

14390. Identify, formulate and solve engineering problems. Pose and solve construction engineering problems with initiative, decision-making skills and creativity. Develop a systematic and creative method of analysis and problem solving. (Additional school competition).

14391. Conceive, project, manage and maintain systems in the field of construction engineering. Cover the entire life cycle of an infrastructure or system or service in the field of construction engineering. (Additional school competition).

### TEACHING METHODOLOGY

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The course consists of 4 hours per week of classroom activity.

The 2.5 hours are devoted to theoretical lectures, in which the teacher presents the basic concepts and topics of the subject, and the 1.5 hours are devoted to show examples and solves exercises (average).

Support material in the form of a detailed teaching plan is provided using the virtual campus ATENEA: content, program of assessment activities and conducted learning, literature.

Although most of the sessions will be given in the language indicated, sessions supported by other occasional guest experts may be held in other languages.

## LEARNING OBJECTIVES OF THE SUBJECT

Students will acquire an understanding of highway construction, preservation, design and planning, as well as the various basic roadway elements. Introduction to railway construction and preservation.

- 1 Ability to design a road according to traffic and other conditions.
- 2 Ability to design the horizontal layout and vertical profile of a transport infrastructure.

Knowledge of road layout, both in plan and elevation, and the coordination between both. Design of road cross sections. Knowledge about traffic. Vehicle movements. Traffic flow and capacity. Earthworks including surface and subsurface drainage. Design and dimensioning of pavements. Knowledge of the characteristics of a railway infrastructure.

Stiffness and deformability of the track. Knowledge of the fundamental characteristics of railway vehicles. Layout of railway. Mixed traffic and tilting vehicles. Stress on roadways. Knowledge of mechanical behavior of a roadway under vertical stresses. Incorporation of transverse stresses. Knowledge of design of the infrastructure and superstructure of the road. High speed railways. Ability to analyze the demand for roads and railways, transport operations and services with the help of ICT, its financing and pricing of tolls.

## STUDY LOAD

Type	Hours	Percentage
Hours medium group	30,0	20.00
Self study	84,0	56.00
Hours large group	30,0	20.00
Guided activities	6,0	4.00

**Total learning time:** 150 h

## CONTENTS

### 0. Presentation

#### Description:

Objectives, faculty, calendar, evaluation system, bibliography.

#### Specific objectives:

Presentation of the course: objectives, faculty, calendar, system evaluation, bibliography.

#### Full-or-part-time: 4h 48m

Theory classes: 2h

Self study : 2h 48m

## 1. ROADS. Construction of earthworks

### Description:

Cut and fill. Subgrade. Geological and geotechnical surveillance. Soil characteristics. Characterization tests. Soil classification (PG-3, ASTM, AASHTO, etc.).

Soil classification problems.

Factors affecting the process of compaction, moisture, compaction type and energy, soil type. Proctor test. Moisture and density measurement.

Soil compaction problems

**Full-or-part-time:** 19h 12m

Theory classes: 4h

Practical classes: 4h

Self study : 11h 12m

## 2. Subgrades

### Description:

CBR test. Plate load test. Subgrade design. Lime and cement-treated soil layers.

Bearing capacity and subgrade design problems.

**Full-or-part-time:** 9h 36m

Theory classes: 2h

Practical classes: 2h

Self study : 5h 36m

## 3. Drainage

### Description:

Hydrological and hydraulic studies. Cross drainage culverts. Surface drainage. Instrucción 5.2-IC "Drenaje superficial"; Water effect on the deterioration of pavements. Design and calculation of sub-surface drainage.

**Full-or-part-time:** 4h 48m

Practical classes: 2h

Self study : 2h 48m

## 4. Pavements

### Description:

Description and functions of road pavements. Factors that must be considered in the project. Basic materials and construction units. Pavement types: flexible, semi-rigid and rigid. Shoulders. Functional and structural characteristics. General design principles. Analytical methods. Empirical methods. Norma 6.1.-IC "Secciones de firme".

Work units. Materials and tests.

Pavement design problems. Norma 6.1-IC "Secciones de Firme".

Work units. Materials and tests.

**Full-or-part-time:** 26h 24m

Theory classes: 5h

Practical classes: 3h

Laboratory classes: 3h

Self study : 15h 24m

## 5. Circulation

### Description:

Traffic Variables. Relationships between traffic variables

**Full-or-part-time:** 2h 24m

Theory classes: 1h

Self study : 1h 24m

## 6. Traffic studies

### Description:

Traffic forecasting. Traffic studies "in situ"

**Full-or-part-time:** 2h 24m

Theory classes: 1h

Self study : 1h 24m

## 7. Capacity and levels of services

### Description:

Definitions and conditions. Level of service (L.O.S.) in freeways.

Exercises

**Full-or-part-time:** 4h 48m

Theory classes: 1h

Practical classes: 1h

Self study : 2h 48m

## 8. Introduction of geometric design

### Description:

- La Instrucción 3.1-IC: approach and presentation.

- \* Horizontal alignment.
- \* Vertical alignment.
- \* Cross section.
- \* Speed Reference.
- \* Visibility.
- \* Terrain.
- \* Coordination horizontal-vertical alignment.

**Full-or-part-time:** 2h 24m

Theory classes: 1h

Self study : 1h 24m

## 9. Horizontal alignment

### Description:

- \* Straight alignments.
  - \* Circular curves.
  - \* Transition curves.
  - \* Relationship between radius and superelevations.
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- \* Shape and characteristic parameters.
  - \* Minimum length.
    - Alignments
    - Straight - Circular
    - Reverse curve (S-shaped curve)
    - C curve (spiral connecting two circular curves with different radius)
    - Combination of two spirals

**Full-or-part-time:** 12h

Theory classes: 2h

Practical classes: 3h

Self study : 7h

## 10. Vertical alignment

### Description:

- \* Calculation axis.
  - \* Grade inclination.
  - \* Ramps and slopes
  - \* The parabola.
- Minimum parameters of the agreements.

Sag vertical curve.

Crest vertical curve

**Full-or-part-time:** 4h 48m

Theory classes: 1h

Practical classes: 1h

Self study : 2h 48m

## 11. Cross section

### Description:

- \* Number of lanes of reference section.
  - \* Cross section on the ground.
- Superelevation transition.

**Full-or-part-time:** 2h 24m

Theory classes: 1h

Self study : 1h 24m

## 12. RAILWAYS. Introduction

### Description:

General concepts, organization of the sector and services.

**Full-or-part-time:** 4h 48m

Theory classes: 2h

Self study : 2h 48m

## 13. Track and Rolling Stock

### Description:

The difficulties of operating a railway line. Main characteristics of a track, both of the infrastructure and of the railway superstructure. Plate track and ballast track. Characteristics of the rolling stock.

**Full-or-part-time:** 9h 36m

Theory classes: 4h

Self study : 5h 36m

## 14. Rail curve circulation

### Description:

The principles of circulation in curves. Geometric design criteria for railway lines. Pendulum and tipping vehicles. Systems to increase the speed of circulation in a railway line.

Problems

**Full-or-part-time:** 9h 36m

Theory classes: 2h

Practical classes: 2h

Self study : 5h 36m

## 15. The geometric quality of the track

### Description:

Parameters that define the geometric quality of the track. Track geometry registration systems. Numerical quantification of the state of the geometric quality of the road. Construction, service and control tolerances. The case of high speed lines.

**Full-or-part-time:** 4h 48m

Theory classes: 2h

Self study : 2h 48m

## 16. Railway infrastructure and superstructure

### Description:

Evaluation of the vertical efforts of a railway line (Interaction track-vehicle): Movements of the railway vehicle, vertical efforts transmitted by the vehicles in the lane, first expressions for the evaluation of the vertical efforts, the works of Birmann and Eisenmann, Prud homme formula and its impact on the design of the track and railway vehicles.

Mechanical analysis and design of the railway infrastructure and superstructure: mechanical analysis of the behavior of the track against the vertical efforts and design of the track. Structural catalogs.

Transversal dynamics: guidance of vehicles, analysis of transversal efforts, practical expressions, lateral resistance of a track and design criteria.

Problems.

**Full-or-part-time:** 16h 48m

Theory classes: 5h

Practical classes: 2h

Self study : 9h 48m

## 17. Turnouts

### Description:

Types of turnouts. The railway diversion and elements that make it up. Characteristics of high speed deviations.

**Full-or-part-time:** 2h 24m

Theory classes: 1h

Self study : 1h 24m

## GRADING SYSTEM

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For assessment purposes, the course consists of two parts: Roads (C) and Railways (FC). Each part will be assessed through partial exams and directed activities.

The mark for the course will be the weighted arithmetic mean of the mark for each of these two parts:

Subject grade =  $\frac{2}{3}$  C grade +  $\frac{1}{3}$  FC grade.

In order to pass, the grade for the subject must be equal to or higher than 5.0.

The grade for each part will be obtained as described below:

In the case of Roads (C) there will be 2 mid-term exams and some evaluable activities to be carried out during the course.

The grade for C will be obtained by weighting the marks for the mid-term exams at 80% and the assessable activities at 20%:

Grade C = 0.80 Mid-term exams + 0.20 assessable activities.

In the case of Railways (FC), there will also be one or two mid-term exams (depending on the distribution of classes during the course) and assessable activities. The FC mark will be obtained by weighting the marks for the mid-term exams at 80% and the assessable activities at 20%:

FC grade = 0.80 Control exams + 0.20 assessable activities.

In addition, once the course has been completed, a re-evaluation exam will be held for those students who, having obtained a numerical mark for the subject, do not obtain a mark of 5.0 or higher.

Once the re-evaluation exam has been carried out, the mark for the part will be considered to be the higher of the two obtained, per course and in the re-evaluation.

Grading criteria and admission to the re-evaluation: students failed in the ordinary assessment who have regularly sat the assessment tests for the failed subject will have the option to take a re-evaluation test in the period set in the academic calendar. Students who have already passed the re-evaluation test of a subject and students who have been marked as failed may not take the re-evaluation test of a subject. The maximum grade in the case of taking the re-evaluation exam shall be five (5.0) and shall be the grade obtained only in the re-evaluation exam. The non-attendance of a student summoned to the re-evaluation test, held in the fixed period, may not give rise to the taking of another test at a later date. Extraordinary evaluations will be carried out for those students who, due to accredited force majeure, have not been able to take any of the continuous assessment tests.

These tests must be authorised by the corresponding Head of Studies, at the request of the lecturer responsible for the subject, and will be held within the corresponding teaching period.

## BIBLIOGRAPHY

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### Basic:

- Kraemer, C.; Pardillo, J.M.; Rocci, A.; Romana, M.; Sánchez,V.; Del Val, M.A. Ingeniería de carreteras: vol. I. 2a ed. Madrid: Mc Graw Hill, 2009. ISBN 978-84-481-6110-1.
- Kraemer, C.; Pardillo, J.M.; Rocci, A.; Romana, M.; Sánchez,V.; Del Val, M.A. Ingeniería de carreteras: vol. II. Madrid: Mc Graw Hill, 2003. ISBN 84-481-3998-4.
- Ministerio de Fomento. Secciones de firme: instrucción de carreteras Norma 6.1 IC. Madrid: Ministerio de Fomento. Dirección General de Carreteras, 2004. ISBN 84-498-0694-1.
- Transportation Research Board. Highway capacity manual 2010. Washington, DC: Transportation Research Board of the National Academies, 2010. ISBN 9780309160773.
- López Pita, A. Infraestructuras ferroviarias [on line]. Barcelona: Edicions UPC, 2006 [Consultation: 09/03/2021]. Available on: <http://hdl.handle.net/2099.3/36850>. ISBN 8483018535.
- López Pita, A. Alta velocidad en el ferrocarril. Barcelona: Edicions UPC, 2010. ISBN 9788498804164.

### Complementary:

- Yoder, E.J.; Witczak, M.W. Principles of pavement design. New York, [NY] [etc.]: John Wiley & Sons., 1975. ISBN 0471977802.
- Huang, Y.H. Pavement analysis and design. 2nd ed. Prentice Hall, 2012. ISBN 9780132726108.



