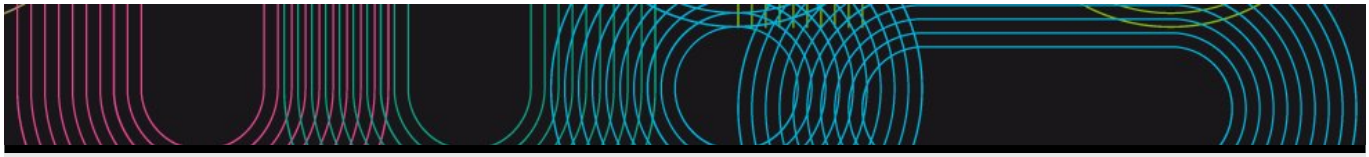

IDENTIFYING DATA				
Theory of structures and industrial constructions				
Subject	Theory of structures and industrial constructions			
Code	P52G381V01404			
Study programme	Grado en Ingeniería Mecánica			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	4th	1st
Teaching language	Spanish			
Department				
Coordinator	González Gil, Arturo			
Lecturers	González Gil, Arturo Suárez García, Andrés			
E-mail	arturogg@cud.uvigo.es			
Web	http://moovi.uvigo.gal			
General description	The main objective of the subject of Theory of Structures and Industrial Constructions is to provide the student with the basic knowledge for the analysis and design of structural elements and systems more frequent in industrial constructions. To do this, the structural typologies and the most common elements in the industrial buildings will be identified. In addition, different tools will be studied for their analysis and design. The students will be also introduced in the management of the current regulations, and in particular the standars for structures made of steel and reinforced concrete, respectively. It is, therefore, a subject that will provide fundamental knowledge for the professional exercise of the graduate in mechanical engineering. In fact, knowledge and ability to calculate and design structures and industrial constructions is one of the competencies that, according to Ministerial Order CIN / 351/2009, of February 9, must be acquired in the official degrees which, as in this case, qualify for the exercise of the Industrial Technical Engineer profession.			

Training and Learning Results	
Code	
B3	Knowledge in basic and technological subjects that will enable students to learn new methods and theories, and provide them the versatility to adapt to new situations.
B4	Ability to solve problems with initiative, decision making, creativity, critical thinking and the ability to communicate and transmit knowledge and skills in the field of Industrial Engineering in Mechanical specialty.
B5	Knowledge to carry out measurements, calculations, assessments, appraisals, surveys, studies, reports, work plans and other similar works.
B6	Capacity for handling specifications, regulations and mandatory standards.
B11	Knowledge, understanding and ability to apply the necessary legislation in the exercise of the profession of Industrial Technical Engineer.
C23	Knowledge and ability to calculate and design of structures and industrial buildings.
D2	Problems resolution.
D5	Information Management.
D8	Decision making.
D9	Apply knowledge.
D10	Self learning and work.
D17	Team working.

Expected results from this subject	Training and Learning Results
(*)Introducción ao coñecemento da Historia da Escritura.	

Knowing the requirements that the structures must meet to fulfill their functions, taking into account the external loads, the security criteria and the bases of calculation	B3 B4 B5 B6 B11	C23	D2 D5 D8 D9 D10 D17
Acquire capacity to convert a real structure into a model for analysis, and vice versa	B3 B4 B5 B6 B11	C23	D2 D5 D8 D9 D10 D17
Identifying the most important typologies and elements used in industrial structures and constructions	B3 B4 B5 B6 B11	C23	D2 D5 D8 D9 D10 D17
Ability to determine stress laws, stresses and deformations in the elements of structures	B3 B4 B5 B6 B11	C23	D2 D5 D8 D9 D10 D17
ENAEE learning outcome: KNOWLEDGE and UNDERSTANDING: LO1.2.- knowledge and understanding of the mathematics and other basic sciences underlying their engineering specialisation, at a level necessary to achieve the other programme outcomes [level of achievement (basic (1), intermediate (2) and advanced (3)) for this learning outcome: Intermediate (2)].	B3	C23	
ENAEE learning outcome: ENGINEERING ANALYSIS: LO2.2.- ability to identify, formulate and solve engineering problems in their field of study; to select and apply relevant methods from established analytical, computational and experimental methods; to recognise the importance of non-technical (societal, health and safety, environmental, economic and industrial) constraints [Intermediate (2)].	B4	C23	D2 D8 D9
ENAEE learning outcome: ENGINEERING DESIGN: LO3.1.- ability to develop and design complex products (devices, artefacts, etc.), processes and systems in their field of study to meet established requirements, that can include an awareness of non-technical (societal, health and safety, environmental, economic and industrial) considerations; to select and apply relevant design methodologies [Intermediate (2)].	B4 B5	C23	D2 D9
ENAEE learning outcome: ENGINEERING DESIGN: LO3.2.- ability to design using some awareness of the forefront of their engineering specialisation [Basic (1)].	B4 B5	C23	D9
ENAEE learning outcome: INVESTIGATIONS: LO4.1.- ability to conduct searches of literature, to consult and to critically use scientific databases and other appropriate sources of information, to carry out simulation and analysis in order to pursue detailed investigations and research of technical issues in their field of study [Basic (1)].	B6 B11		D5
ENAEE learning outcome: INVESTIGATIONS: LO4.2.- ability to consult and apply codes of practice and safety regulations in their field of study [Advanced (3)].	B6 B11		
ENAEE learning outcome: ENGINEERING PRACTICE: LO5.1.- understanding of applicable techniques and methods of analysis, design and investigation and of their limitations in their field of study [Intermediate (2)].		C23	D9
ENAEE learning outcome: ENGINEERING PRACTICE: LO5.2.- practical skills for solving complex problems, realising complex engineering designs and conducting investigations in their field of study [Basic (1)].	B4 B5		D2 D9
ENAEE learning outcome: ENGINEERING PRACTICE: LO5.3.- understanding of applicable materials, equipment and tools, engineering technologies and processes, and of their limitations in their field of study [Basic (1)].			D8 D9
ENAEE learning outcome: ENGINEERING PRACTICE: LO5.4.- ability to apply norms of engineering practice in their field of study [Intermediate (2)].	B6 B11		D9

Contents
Topic

Unit 1. Introduction to the analysis and design of structures	Objectives and development: This theme will serve like an introduction to the structural analysis. It will present the fundamental considerations for the idealisation and the analysis of a structure, will identify the main types of structures and their elements and, finally, will describe the different types of loads in a structure. Index: 1.1 Analysis and structural design 1.2 Classification of structures 1.3 Types of loads on structures 1.4 Idealisation of structures 1.5 Structural behaviour: load distribution 1.6 Basic principles of the structural analysis
Unit 2. Industrial Constructions: Typology and Constructive Elements	Objectives and development: This theme will introduce the concept of industrial urbanism and identify the different types of structures used in industrial buildings, as well as their basic constructive elements. Also, the student will be introduced to the systems and construction processes used in industrial buildings. Index: 2.1 General information on architecture and industrial urbanism 2.2 Types of structures in industrial buildings 2.3 Building elements: Foundations 2.4 Building elements: Beams, pillars and slabs 2.5 Building elements: Enclosures and covers
Unit 3. Normative frame in the calculation and design of structures and industrial constructions	Objectives and development: The codes currentluy in force for the design of industrial constructions and the calculation of their structures will be presented. The criteria of structural security that govern the calculation of structures in Spain and in the European Union will be studied. This includes the determination of the loads on a structure. Besides, an apporach to different criteria that must be taken into account in the design and the construction of industrial buildings: evaluation and prevention of risks in the construction phase, security of utilisation and accessibility, energy saving and use of renewable energies, healthy indoor environment, noise protection, etc. Index: 3.1 Regulatory framework for industrial constructions 3.2 The Technical Building Code (CTE) 3.3 Loads according to the CTE 3.4 Structural security according to the CTE: verification of Limit States 3.5 Load combination 3.6 Social, environmental, security and health aspects in industrial buildings
Unit 4. Introduction to the design of metal structures	Objectives and development: The fundamentals of the design and calculation of metal structures will be explained. The main characteristics of steel structures used in industrial buildings will be presented. An introduction will be made to the sizing and verification of the main elements of steel structures. Index: 4.1 Introduction to metal structures 4.2 Steel: classes and main characteristics 4.3 Standard steel sections 4.4 Introduction to the calculation of steel elements subjected to tensile, compression and bending forces
Unit 5. Introduction to the design of concrete structures	Objectives and development: The main characteristics and behavior of the concrete structures used in industrial buildings will be described. The properties and applications of concrete as a construction material (bulk, reinforced and prestressed concrete) will be studied. Concrete selection and identification criteria will be introduced. Index: 5.1 Introduction to concrete structures 5.2 Types of concrete used in buildings 5.3 Reinforced concrete: components and structural behavior 5.4 Selection and identification of concrete as a building material

Unit 6. Analysis of reticular structures with articulated knots	Objectives and development: The main features of bar structures with articulated knots will be defined and their main types will be identified. Different analytical methods will be studied to determine stresses and deformations in both isostatic and hyperstatic structures. The results obtained with this type of analysis will be related to the fundamentals of metal structures design, seen in unit 4. Index: 6.1 Characteristics of structures with articulated knots 6.2 Analysis of isostatic structures: method of knots 6.3 Analysis of isostatic structures: method of sections 6.4 Analysis of isostatic structures: determining deformations 6.5 Analysis of hyperstatic structures 6.6 Anlaysis of articulated frames and articulated beams
Unit 7. Analysis of reticular structures with rigid knots	Objectives and development: The behavior of bar structures with rigid knots will be analysed. The fundamentals of the method of Cross of distribution of moments will be presented as tool of analysis of this type of structures. This method will be applied to determine the internal forces in hyperstatic beams and frames. The results obtained with this type of analysis will be related to the fundamentals of design of metal and concrete structures, seen in unit 4 and 5, respectively. Index: 7.1 Characteristics of structures with rigid knots 7.2 Fundamentals of the Cross method 7.3 Analysis of hyperestatic beams using the Cross method 7.4 Analysis of frames using the Cross method
Unit 8. Cables and Arches	Objectives and development: The fundamentals of the structural analysis of cables and arches will be studied. Both the cables supporting to puntual and distributed vertical loads will be analysed. Three-Hinged arches will be studied as a basic case of the analysis of arches. Index: 81 General characteristics of cables 8.2 Analysis of cables supporting vertical concentrated loads 8.3 Analysis of cables supporting vertical distributed loads 8.4 General characteristics of arches 8.5 Analysis of three-hinged arches
Unit 9. Buildings in the Spanish Navy	Objectives and development: Some of the most relevant aspects of constructions in the Armed Forces, and in particular the Spanish Navy, will be estudied. Different cases of buildings present in military units and bases will be analyzed from the constructive and structural point of view. It is intended that this unit serves to review and apply some of the most relevant content of the course through its contextualization in a more familiar environment, and if possible more motivating, for the students. Index: 9.1 Examples of buildings in military environments 9.2 Management of building projects in the Navy
Practice 1. Identification and idealization of structures	Objectives and development: With this practice, it is intended to complement the contents of the first two units of the subject, as well as to review basic knowledge of structural stability, acquired in previous courses. Different examples of real structures will be proposed for the student to idealize, determine their external loads and analyze their stability. In addition, this practice will be complemented with a visit to several buildings of the ENM in which students will be able to identify different types and structural elements studied during the course.
Practice 2. Determining design loads on industrial buildings	Objectives and development: This practice aims to introduce the student to the management of the current regulations applicable to the design of structures, in particular to determining loads according to CTE. For this, an exercise is proposed in which the students must determine the loads actuating on different structural elements of an industrial warehouse. This practice is related to the first three units of the subject.

Practice 3. Sizing structural steel elements	Objectives and development: With this practice, the students are expected to complement and expand their knowledge on calculation and combination of loads, applying them to the dimensioning of different elements of steel structures. For this, the student will solve one practical case raised by the lecturer. This practice is related to units 2, 3 and 4.
Practice 4. Introduction to reticular structures with articulated and rigid knots	Objectives and development: This practice intends to introduce the student to the study of structures based on bars with articulated knots or with rigid knots, which will be approached, respectively, in units 6 and 7 of the subject. Different demonstrative assemblies of models of articulated knot and rigid knot bar structures will be carried out, in such a way that students can visualize and understand the behavior of these structural typologies under different external loads.
Practice 5. Analysis of deformations in trusses	Objectives and development: In this practice, deformation measurements will be made in a truss model under different load conditions. Likewise, a theoretical approach to the experimentally measured results will be carried out. The main objective is to reinforce the knowledge acquired in unit 6 of the subject.
Practice 6. Introduction to the use of professional structural calculation software	Objectives and development: In this practical session, the student will be introduced to the management of professional structural calculation programs with a dual objective: i) to promote the consolidation of basic knowledge on design and calculation of structures acquired throughout the course; ii) show the possibilities offered by a professional structure calculation software. There will be a brief presentation of the software available at the center (Autodesk Robot Structural Analysis) and the sizing of different structural elements and simple structures will be carried out
Practice 7. Social, environmental, safety and health aspects in the design and construction of industrial buildings	Objectives and development: Students, working in groups of three to five people, must present and defend a work on different social, environmental, safety and health aspects that according to the Technical Building Code and other reference regulations must be taken into account in the design and the construction of industrial buildings. These works will be raised by the lecturers of the subject during the teaching of unic 3. The result of this practice will be evaluated within the Group Work item (TG), according to what is established in the Assesment item of this teaching guide.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	28	42	70
Laboratory practical	14	7	21
Seminars	7	0	7
Problem solving	28	16	44
Mentored work	0	8	8

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Lecturing	The methodology of these classes will approximate to a masterful participatory session. The fundamentals of each topic will be explained and explanatory examples will be presented. Also, the student will be guided to study the contents of the subject in an autonomous way. As an expository method, the digital screen available in the classroom will preferably be used. As far as possible, copies of the presentation slides will be provided to the students prior to the class, focusing the efforts of the lecturer and students on the exposition and understanding of the knowledge. Additionally, collaborative learning will be encouraged in the classroom through group activities. The aim is to motivate the student in the research activity, and encourage personal skills while sharing problems and solutions. With a dedication that will vary throughout the course and depending on the specific needs of the subject, part of the classroom classes will be dedicated to solving problems by teams (problem-based learning).

Laboratory practical	The practical teaching will aim to apply, expand and consolidate the concepts studied in the theoretical classes. With the idea of promoting both the creativity and technical skills of the student, a series of sessions are presented, which include, on the one hand, the performance of laboratory practices, and on the other, the study of cases and the resolution of problems and/or exercises. These sessions will deal with the experimental analysis of deformations in structures, the resolution of exercises of structural analysis by classical methods and with computer software, the handling of specifications, regulations and obligatory standards in the design of industrial buildings. These classes will begin with a presentation of the practice by the lecturer, and if necessary, with an explanation of new theoretical concepts that are necessary for its realisation. Subsequently, the students will carry out the practice in question working in small groups, and under the supervision of the lecturer. At the end of each practice, each group of students must submit a summary report with the results obtained.
Seminars	Classes designed to solve problems and/or exercises and to study cases, which students must carry out individually or in group. The fact that the number of students in these classes is reduced (around 10), allows a greater proximity between lecturer and student, which facilitates the understanding and the comprehension of the fundamental concepts of the subject
Problem solving	Intensive course (15 hours) for those students who have failed the subject at first call, prior to the exam in second call. Group tutoring with the lecturer. Doing examans. Assessment tasks and reinforcement hours.
Mentored work	Students, working in groups of three to five people, must present and defend a work on different social, environmental, safety and health aspects that according to the Technical Building Code and other reference regulations must be taken into account in the design and the construction of industrial buildings. These works will be proposed by the teaching staff of the subject during the teaching of unit 3 and will be presented in the hours allocated to the 7th laboratory practice.

Personalized assistance

Methodologies	Description
Problem solving	In the scope of the tutorial action, we distinguish actions of academic tutoring and personalised tutoring. The students will have at their disposal hours of academic tutoring in which they will be able to ask any question related to the contents of the subject, its organisation, evaluation, etc. These tutorials can be individualised or in a group. Notwithstanding, group tutorials will be encouraged for solving problems or clarifying different contents of the subject. In addition, the lecturer will be available for the student to comment or ask for advice on any circumstance that prevents him/her from adequately following the subject (personalised tutorials). With the combination of these two types of tutorial action, we aim to achieve an academic-personal balance that allows the student to achieve their goals in the most effective way. The faculty of this subject will be available for tutorials in the schedule published on the website of the centre, as long as the students confirm in advance by email their interest in attending them. However, the students may arrange a tutorial with the lecturer at any time (not necessarily in this schedule). Finally, the teaching staff will be able to answer the students' questions by telematic means (email, videoconference, forums on online teaching platforms, etc.).

Assessment

	Description	Qualification	Training and Learning Results		
Lecturing	Written tests: theoretical questions and problems The written tests aim to evaluate the learning of all the theoretical contents of the subject. There will be two partial tests and one final exam. Each partial test will contribute 15% of the final grade of the student. The final exam, which will cover all the subject matter, will have a weight of 40% in the final grade. The written tests will consist of a series of questions and exercises that give priority to the conceptual and logical reasoning, in order to verify the intellectual maturity of the students to obtain conclusions from the notions or theories exposed in class. All tests will be evaluated for a total of 10 points.	70	B3 B4 B5 B6 B11	C23	D2 D5 D8 D9 D10
Laboratory practical	The students must present a report of practices for each laboratory practice performed (in case the practice is done in group, only one practice will be delivered per group). Each report will be evaluated on 10 points. The final grade of practices will be the average value of the grades obtained in each practice delivered.	10	B3 B4 B5 B6 B11	C23	D2 D5 D8 D9 D10 D17
Seminars	Throughout the course (in particular during the seminar hours), different exercises will be proposed to students, who may do them in groups or individually. Each of these exercises will be evaluated over 10 points. The grade of this item will be the average value of the grades obtained in each deliverable.	10	B3 B4 B5 B6 B11	C23	D2 D5 D8 D9 D10 D17

Mentored work	Group work that must be accompanied with a memory and an oral presentation. The work will be valued on a maximum of 10 points.	10	B3 B4 B5 B6 B11	C23	D2 D5 D8 D9 D10 D17

Other comments on the Evaluation

A numerical rating system with values between 0 and 10 will be used, according to the current legislation (R.D. 1125/2003 de 5 de septiembre, B.O.E. nº224 de 18 de septiembre).

Ordinary call: continuous evaluation

The continuous evaluation method (EC) will assess the results achieved by the students in the different activities carried out throughout the course, which will be grouped as follows: Final Test (PF), Theoretical-Practical Controls (CT), Lab Reports (MP), Evaluables Exercises (EE), and Group Work (TG). The grade of each part will be calculated as the arithmetic mean of the items made up to the moment of the evaluation in that part.

There will be two tests of evaluation of theoretical-practical knowledge (CT) throughout the course. The student must present a report for each laboratory practice provided that it is indicated in the realization of the same, which will be evaluated in item MP. In the seminar and / or theory class hours, the student may be offered the completion and delivery of different exercises, which will be evaluated in item EE. In the event that a student is unable to attend a session (due to a justified reason) in which exercises that can be evaluated are carried out, the student must notify the lecturers by email so that they have a record and this circumstance is taken into account at the time of the evaluation. In addition, the students must carry out and present a group work on the social, environmental, safety and health aspects in the design and construction of industrial buildings (see practice 7), which will be evaluated in item TG. The final continuous assessment test (PF) will include all the contents of the subject and will have a weight of 40% in the final grade of continuous assessment.

The grade of the continuous evaluation (NEC), will be the result of applying the weighted average to all the evaluated parts; that is, it will be calculated as follows:

NEC= 0.4 PF + 0.15 CT1 + 0.15 CT2 + 0.1 MP + 0.1 EE + 0.1 TG

The student will pass the subject by continuous evaluation when each and every one of the following requirements is met:

1. Have completed all evaluable tasks (except duly justified cases)
2. Have a score of at least 4 points out of 10 in the continuous assessment final exam (PF)
3. Have a NEC value greater than or equal to 5 points (out of 10)

In case of not fulfilling any of the first two requirements, the final grade of continuous evaluation will be equal to the minimum value between NEC and 4 points.

Ordinary call: ordinary exam

Those students who fail to pass the subject by the continuous assessment method, must do the ordinary exam, where all the competences of the subject will be assessed. The results of this exam will suppose 100% of the student's final grade, being an essential requirement to pass the course to obtain a grade of at least 5 points out of 10.

Students who have passed the subject by continuous evaluation will have the possibility of taking the ordinary exam to improve their grade.

Extraordinary call

Students who have not passed the subject in the ordinary call will take an extraordinary exam that will have the same format and the same requirements as the ordinary exam.

Academic integrity:

Students are expected to show adequate ethical behaviour, committing to act honestly. Based on article 42.1 of the Regulation on the evaluation, qualification and quality of teaching and the student learning process of the University of Vigo , as well as point 6 of the fifth rule of Order DEF/711/2022, of July 18, which establishes the requirements for evaluation, progress, and ongoing enrolment in military educational training centres for incorporation into the ranks of the Armed Forces, **any violation of academic integrity in the assessment process, as well as the cooperation in it will result in the assignment of a failing grade to the student (zero) for the entire course in the corresponding**

assessment opportunity, regardless of the percentage of importance that the test in question had in the overall continuous assessment and independently of other disciplinary actions that may be applied.

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Urbán Brotóns, P., **Construcción de estructuras metálicas**, 5ª ed., Ed. Club Universitario, 2015

Recommendations

Subjects that it is recommended to have taken before

Elasticity and additional topics in resistance of materials/P52G381V01303

Other comments

For a correct follow-up of this subject, the students must have solid knowledge of vector calculus and master the concept of static equilibrium. In addition, they must have the ability to analyse tensions and deformations in elementary structures. They should also be familiar with the mechanical properties of structural materials such as steel. It is therefore highly recommended that the students have completed and passed the following subjects of the curriculum: Physics I, Materials Science and Technology, Resistance of materials and Elasticity and Advanced strength of materials.
The knowledge acquired in the structural analysis part of this subject can be useful to the student in the follow-up of subjects such as Machine design (second term of the fourth year) or Theory of the ship and shipbuilding (first term of the fifth year). Also, the knowledge acquired in the construction part will be complemented by the subject of Basics of topography, which is only taught to students of Marine Corps.