PERSONA CIÈNCIA EMPRESA
UNIVERSITAT RAMON LLULL

COURSE: STRENGTH OF MATERIALS

SUBJECT MATTER: Fundamentals of Mechanical Engineering
MODULE: Core Topics of Industrial Engineering
PROGRAM: Degree in Chemical Engineering

GENERAL CHARACTERISTICS

Type: ☐ Basic formation, ☑ Compulsory, ☐ Elective

☐ Final Degree Project, ☐ Internships

Duration: Semestral **Semester**: 8th
Number of ECTS credits: 3
Language(s): English, Spanish, Catalan

DESCRIPTION

SHORT DESCRIPTION AND JUSTIFICATION

The Strength of Materials, also known as the Mechanics of Deformable Solids, is the discipline that studies the internal solicitations and deformations that occur in the body subjected to external loads which can cause failure. This course provides the student with the knowledge and ability to determine the stresses and corresponding stresses, deformations and displacements to which a component or structural element is subjected, in order to establish the bases required for the calculation of structures associated with the environment of chemical engineering, such as pressure vessels, beams, pipes, among others. The subject deals with fundamental concepts such as rigidity, strength and structural stability, as well as the most common modes of mechanical failure in the industry.

It is an introductory course that combines the conceptual development of the basic principles of materials mechanics, with an eminently practical character that is linked to the development and acquisition of skills and training objectives. This is an essential basis for tackling the following subjects in the discipline, such as Industrial Structures and Constructions in the Master's Degree in Chemical Engineering.

The purpose of the subject is that students can develop simple methods of calculation, acceptable from a practical point of view, of the most common typical elements of structures and machine elements, using various approximate procedures. The need to obtain concrete results when solving practical problems forces them to resort to simplifying hypotheses that can be justified by comparing the calculation results with the experimental tests. The simplifications affect the geometry of the element, the joints and supports, the system of applied forces and the properties of the materials. The problems addressed are mainly of two types.

a) **Dimensioning:** the aim is to determine the most appropriate material, shape and dimension of a resistant element so that it can perform its function safely and at the lowest cost.
b) **Verification:** when the material, shape and dimensions have already been determined, and it is necessary to know if they are adequate to resist the state of acting solicitations.

The **specific formative objectives** of the subject are:

- To know the principles of elasticity, mechanics and strength of materials and the behaviour of deformable solids.
- Identify the internal forces that occur in a solid as a consequence of the application of external forces.
- Calculate the stresses, deformations and displacements of elemental structural elements.
- To know the methodologies of dimensioning and verification of structural elements.
- Know how to use bibliographic and technical information related to this subject.

COMPETENCES

The **specific** and **transversal competences** that are addressed in the subject are:

- To be able to understand and apply knowledge of Chemistry and Engineering for its application in the field of Chemical Engineering. (CB1, E2)
- Be able to identify, formulate and solve basic problems in Mathematics, Chemistry, Physics, Computer Science, Biology, Economics and Graphic Expression and problems in the fields of Chemical Engineering and Chemistry. (CB2, E7)
- Be able to analyze, integrate and interpret data and information from the field of Chemical Engineering. (CB3, E8)
- Be able to work in a team. (CB4, T1)
- Knowledge and use of the principles of strength of materials. (CRI8)

PREREQUISITES

According to the program planning and academic regulations.

CONTENTS

1. Introduction - The concept of stress

a) Credits: 0,3 ECTS

b) Contents:

This first thematic block introduces the discipline of material mechanics, revising the concept of structural statics, defining the concept of axial stress and shear stress, exposing the Saint-Venant's principle and the concept of stress concentrator, as well as the meaning of the safety factor.

c) Learning outcomes:

At the end of the block the student should be able to understand the concept of stress and the effect of directionality of loads, understand the concept of stress concentrator and strategies to minimize its effect, and understand the meaning of the safety factor and its relevance in structural design. In addition, one must be able to perform simplified axial and tangential stress calculations from simple load states and determine safety factors.

2. Stresses and strains

a) Credits: 0,9 ECTS

b) Contents:

In the second thematic block, the concept of normal stress and the relationship with deformations is explored, the Hook's Law and the stress-strain diagram are explained, as well as their relationship with the properties and constitutive laws of materials. Next, the elongation of prismatic solids and their relationship with unit deformation is studied, the Poisson coefficient is defined, and the concept of static indetermination, thermal deformation and hydrostatic compressibility is explained. Finally, the concept of shear stress and angular distortion is defined to expose the generalized Hooke's Law.

c) Learning outcomes:

At the end of the block the student must be able to discern between the concepts of elongation, unit deformation and angular distortion, know the relationship with the constitutive laws of elastic materials, and understand and determine the constitutive relationship and its matrix representation from the generalized Hooke's Law. In addition, one must demonstrate that is able to determine the elastic modulus and Poisson coefficient of a material and relate it to the stress-strain diagrams. It must also be able to identify and calculate elongation by thermal effects and hydrostatic compression.

3. Torsion

a) Credits: 0,2 ECTS

b) Contents:

In the third thematic block, the concept of stress and deformation of axes is introduced, and the effect of stress concentrators is examined.

c) Learning outcomes:

At the end of the block, the student must be able to determine the effect of torsion on axes, identifying the acting loads, deformations, generated stresses and the relationships between the variables of the problem.

4. Bending

a) Credits: 0,6 ECTS

b) Contents:

The fourth thematic block deals with the study of prismatic elements subjected to pure and composite bending stresses, analysing the kinematics of the section, introducing the concept of neutral fibre and determining the relationship between stress and unit deformation. Finally, the effect of the eccentricity of the axial load and the moments acting outside the main plane are evaluated.

c) Learning outcomes:

At the end of the block, the student must demonstrate that understands the concept of bending in prismatic elements, and that is able to determine analytically the relationship between the variables of the problem, such as applied loads, generated solicitations and tensions, as well as the geometry of the section. In addition, one must be able to determine the position of the neutral fiber and understand its significance and the relationship with the configuration and arrangement of external loads in states of pure and composite bending.

5. Analysis and beam dimensioning

a) Credits: 0,5 ECTS

b) Contents:

In the fifth thematic block, the concepts presented in the previous topic are put into practice for the analysis and dimensioning of beams subjected to bending. In particular, the basic considerations and methodology for the design of prismatic beams are described, the bending and shear stress diagrams are represented, and the relationships between loads, solicitations, turns and displacements are presented in order to finally present the general elastic equation for the calculation of the displacements and turns of the beam sections.

c) Learning outcomes:

At the end of the block the student must demonstrate that is able to understand and differentiate between the concepts of loads, solicitations and generated tensions (as well as the analytical relations between them) in a prismatic element on which different loads act causing a state of flexion. In addition, one must demonstrate that understands the meaning of the graphic representations of the solicitations from which one must pose and solve problems of dimensioning and verification of the sections of beams to deflection, determining safety conditions (strengths) and functionality (displacements and slopes).

6. Transformation of stresses and strains

a) Credits: 0,4 ECTS

b) Contents:

The sixth and final thematic block defines the concept of flat stress and deformation, the concept of stresses and main directions and presents the methodology for their determination from Mohr's circles. Next, the creep criteria for ductile materials are described, breaking criteria for brittle materials and finally the tensile state of thin-walled spherical and cylindrical deposits is analysed for design and verification.

c) Learning Results:

At the end of the block the student must demonstrate that one knows the trigonometric relationships for the transformation of the two-dimensional states of stress and deformation, and the graphical resolution tools. In addition, one must be able to determine the principal stresses and directions, interpret the result and relate it to the criteria of creep and breakage of the materials. Finally, it must demonstrate that it is capable of facing simplified problems of dimensioning and verification of circular and spherical deposits from stress analysis.

METHODOLOGY

LEARNING ACTIVITIES

Learning Activities	Hours	ECTS Credits	Competences
Lectures	17	0,6	CB1, E2, CB2, E7, CB3, E8, CB4, T1, CRI8
Case and Problem-Solving Sessions	9	0.3	CB1, E2, CB2, E7, CB3, E8, CB4, T1, CRI8
Seminars			
Practical & Lab Work	16	0,6	CB1, E2, CB2, E7, CB3, E8, CB4, T1, CRI8
Presentations	3	0,1	CB1, E2, CB2, E7, CB3, E8, CB4, T1, CRI8
Personal study	32	1.2	CB1, E2, CB2, E7, CB3, E8, CB4, T1, CRI8
Assessment Tasks (Exams, Continuous Assessment...)	5	0,2	CB1, E2, CB2, E7, CB3, E8, CB4, T1, CRI8
TOTAL	**82**	**3,0**	

TEACHING METHODOLOGY

The lecture sessions combine expository parts with practical activities, which give rise to various models of interaction in the classroom: the descriptive dynamic model in which the professor exposes the contents, the demonstrative dynamic model in which the professor performs tasks and solves problems, and the active dynamic in which the student has to solve individually or in a group, various supervised problems raised in the classroom. Besides, students must complete their training by solving problems individually and autonomously, or with the help of the professor in the hours available for consultation. The aim is for the student to be involved in the learning process.

In the laboratory sessions, a series of practical experiences are carried out with simple structural elements, with individualised monitoring by the professor, thus complementing the learning of the concepts and fundamentals of the subject presented in the lecture sessions.

For the personal study, the student mainly has a specific material and self-content of the course in electronic format on the Moodle teaching platform, in addition to a list of basic bibliographical references.

ASSESSMENT

ASSESSMENT METHODS

Assessment Methods	Weight	Competences
Final Exam	35%	CB1, E2, CB2, E7, CB3, E8, CRI8
Midterm Exam/s	-	
Follow-up Activities	30%	CB1, E2, CB2, E7, CB3, E8, CRI8
Reports and Presentations	24%	CB1, E2, CB2, E7, CB3, E8, CB4, T1, CRI8
Lab or Field Work	10%	CB4, T1, CRI8
Projects	-	
Host Student Evaluation	-	
Participation	1%	CB1, E2, CB2, E7, CB3, E8, CRI8

LEARNING OUTCOMES

Overall, the student must demonstrate ability for the interpretation and analysis of the physical concepts linked to the principles of elasticity, mechanics and strength of materials and the behaviour of deformable solids, must be able to identify the internal forces that appear in a solid as a consequence of the application of external forces and must be able to calculate the stresses, deformations and displacements of elemental structural elements. Likewise, it must know how to apply the methodologies of dimensioning and verification of structural elements and know how to use the bibliographic and technical information related to this matter.

At a more specific level, the learning results have been included in each of the thematic blocks of the previous section.

QUALIFICATION

The evaluation of the subject will consider all the activities detailed in the table of evaluation methods with their corresponding weight. It is compulsory the attendance, realization and delivery of the reports of all the practical activities to pass the subject. A **minimum score of 5 out of 10** is required in the internship report. Otherwise, the conditions for taking the final exam will not be met. In the final exam a **minimum grade of 4 out of 10 is required**, otherwise the overall grade of the subject will be the grade of the final exam.

A high level of attendance (>75%) is also required to pass the course. A lower attendance than indicated, without justified cause, implies the direct suspension of schooling of the subject.

ASSESSMENT OF THE COMPETENCES

For the evaluation of CB1/E2, CB2/E7 and CB3/E8 competences, the weighted scores of the activities included in the evaluation methods (partial evaluations, non-attendance activities and final examination) will be used as indicators.

The competences CB4/T1 and CRI8 will be evaluated from the performance of the work and the laboratory report and from the participation in the classroom (face-to-face activities). The qualification is established within one of the four levels or degrees of mastery of the competence defined above, being these:

- Level 1: does not make an effort to acquire the competence and does not demonstrate that it has been acquired or rarely does so.
- Level 2: one study, train and demonstrate that sometimes applies the competency.
- Level 3: one has learned the competence, and, in his conduct, it is demonstrated that applies it.
- Level 4: one has integrated competence in the behaviour habits.

These levels correspond to the four levels of qualification (fail, satisfactory, good, excellent).

BIBLIOGRAPHY

Basic

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- J. M. Gere & B. J. Goodno. Mechanics of Materials, 8th ed. Cengage Learning, 2012. ISBN-13: 978-1111577735.
- R. C. Hibbeler. Mechanics of Materials, 8th ed. Pearson Prentice Hall, 2011. ISBN-13: 978-0-13-602230-5.

Complementary

- L. Ortiz Berrocal. Resistencia de Materiales. 3rd ed. McGraw-Hill, 2007. ISBN-13: 978-8448156336.
- Pytel & J. Kiusalaas. Mechanics of Materials, 2nd ed. Cengage Learning, 2012. ISBN-13: 978-0-495-66775-9.
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- J. Case, A. H. Chilverand & C. T. F. Ross. Strength of Materials and Structures, 4th ed. John Wiley & Sons, Inc., 1999. ISBN 0-471-40052-1.

DOCUMENT HISTORY

PREVIOUS REVISIONS
January 2018, Dr. Marco A. Pérez
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CURRENT REVISION
January 2019, Dr. Marco A. Pérez