Universidad Zaragoza

**Year : 2019/20**

# 30123 - Resistance of Materials

## Syllabus Information

**Academic Year:** 2019/20
**Subject:** 30123 - Resistance of Materials
**Faculty / School:** 175 - Escuela Universitaria Politécnica de La Almunia
179 - Centro Universitario de la Defensa - Zaragoza
**Degree:** 425 - Bachelor's Degree in Industrial Organisational Engineering
457 - Bachelor's Degree in Industrial Organisational Engineering
563 - Bachelor's Degree in Industrial Organisational Engineering
**ECTS:** 6.0
**Year:** 3
**Semester:** Second semester
**Subject Type:** Compulsory
**Module:** ---

# 1.General information

## 1.1.Aims of the course

The subject and its expected results respond to the following approaches and objectives:

Strength of materials is a compulsory course for all students of technical degrees, since it aims at setting up the criteria that will allow them to determine the material, shape and size that must be given to any structural elements that they might have to design in a given project in their future professional activity.

A major goal of the course is that graduates acquire a number of cross-curricular, technical, systemic, participatory and personal competences that will be listed in the following section. These competences are acquired through work on specific problems, which include:

- Dealing with the effects caused by the action of external loads that act on a deformable system

- Analyzing the internal forces induced in its different components

- Calculating the corresponding deformations and the relationships that exist between the action of external loads, induced forces and deformations

- Based on the analysis, making decisions about the materials to be used, the size and correct shape of the parts that make up a given system, or deciding if a component is capable of withstanding a proposed load system.

Although for an accurate research on Strength of materials it is necessary to be knowledgeable about the Theory of Elasticity, in this course only some basic notions of Elasticity (concepts of deformations, stresses and the elastic problem) that allow to understand and use the simplifying hypotheses that are used in Strength of materials for the practical solving of real problems in engineering correctly will be given. In this way, the mathematical accuracy of the Theory of Elasticity will be partially sacrificed, with the aim of obtaining sufficiently valid solutions for the resolution of problems of particular cases of elements (beams, bars, containers, etc.) subjected to different types of solicitations producing contractions, bendings, torsions, etc.

## 1.2.Context and importance of this course in the degree

The theory of rigid solids was studied in the course on "Mechanics" based on the hypothesis that when a solid is subjected to a loading system, it remains perfectly rigid, that is, the distances between its points do not vary and the solid does not experience any type of deformation.

In this course "Strength of Materials" the mechanics of deformable solids will be studied since all the structures and real machines are deformed under the loads to which they are subjected.

The Theory of Elasticity is considered as that part of the Mechanics that studies elastic deformable solids of engineering interest; that is, those solids that recover their original shape when the mechanical or thermal actions that deformed them stop acting. Its field of research is very wide, Strength of Materials being a more practical part of this theory.

Thus, Strength of Materials can be defined as the set of those techniques that allow to study the mechanical behavior of elastic solids formed by a small number of prismatic parts, interconnected with each other and supporting mechanical and thermal actions.

### 1.3.Recommendations to take this course

To take this course it is recommended to have passed Physics I and Mathematics I and II of the first year of the degree as well as Mechanics and Mathematics III of the second year of the degree.

In particular, previous knowledge in infinitesimal calculus, integral calculus, differential equations, mass geometry (calculation of gravity centers and moments of inertia), statics and good spatial representation skills will be required.

## 2.Learning goals

### 2.1.Competences

C04 - Ability to solve problems and make decisions with initiative, creativity and critical reasoning.

C07 - Ability to use techniques, skills and tools necessary to practise engineering.

C10 - Ability to manage information, skills to handle and apply technical specifications and the necessary legislation to practise engineering.

C11 - Ability to continue learning and develop self-learning strategies.

C31 - Knowledge and use of the principles of mechanics of materials.

### 2.2.Learning goals

To pass this subject, the students must demonstrate the following competences ...

- Understanding of the concepts of stress and strain and knowing how to relate them through the elastic behavior equations, in order to solve problems of simple three-dimensional elastic solids.
- Knowing to calculate and represent stress diagrams of bars and simple structures.
- Knowing to solve torsion problems in shafts and simple three-dimensional structures.
- Knowing to solve compound bending problems in beams and simple structures.
- Understanding the phenomenon of bar buckling and knowing how to solve buckling problems of isolated bars.
- Knowing how to distinguish between isostatic and hyperstatic problems and knowing different strategies for solving such hyperstatic problems.
- Knowing how to use a computer program for structural analysis.

### 2.3.Importance of learning goals

This subject offers training with contents of immediate application and development in the cu

## 3.Assessment (1st and 2nd call)

### 3.1.Assessment tasks (description of tasks, marking system and assessment criteria)

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**Evaluation Activities**

The students must demonstrate that they have achieved the expected learning outcomes, that the

1. **Continuous evaluation system**: This will be done throughout the semester with the purpose o

    1.1. Written Tests: Throughout the semester written tests will be carried out on the conte

    1.2. Simulation and Laboratory Sessions: Several practical sessions will take place in co

    1.3. Evaluation Exercises without Official Grade: This means that the student is able to

2. **Global Evaluation System:** A final written exam will be carried out at the end of the seme

    2.1. Written Test: This will consist of problem solving and theoretical-practical questio

    2.2. Practical Test: The student will be confronted with the practical realization of sim

**Evaluation Criteria**

To pass the subject it is necessary to separately pass both, the practical and written exams.

- Practical exams: Active participation in the practical sessions and evaluation of the hand

- Written exams: The theoretical part of the subject can be passed by fulfilling the requirem

· **Continuous evaluation system:**

- Grade ? 4.5 (out of 10) on the mid-semester exam.

- Grade ? 4.5 (out of 10) on the final exam of the second part.

- Weighted grade average of the written test ? 5, according to the following formula:

NFE = NA * 0.4 + NB * 0.6

NA, NB: Grade of the mid-semester and end-of-the-semester exam respectively; NFE: Final exam g

· **Global evaluation system:**

- Grade ? 5 on the final exam.

- In the examination session in June, the exam is made up of two parts (A and B). The fina

NFE = NA * 0.4 + NB * 0.6

NA, NB: Grade of the first and second parts of the subject; NFE: Grade of the final exam

**Condition to pass the subject:** To pass the practical and the written exams separately. The fir

Final Grade = NFP * 0.1 + NFE * 0.9

If the conditions to pass the subject are not fulfilled, the subject will be failed and the fi

# 4.Methodology, learning tasks, syllabus and resources

## 4.1.Methodological overview

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Strong interaction between the teacher/student. This interaction is brought into being through a division of work and responsibilities between the students and the teacher. Nevertheless, it must be taken into account that, to a certain degree, students can set their learning pace based on their own needs and availability, following the guidelines set by the teacher.

The current subject (Strength of Materials) is conceived as a stand-alone combination of contents, yet organized into three fundamental and complementary forms, which are: the theoretical concepts of each teaching unit, the solving of problems or the resolution of questions and laboratory work, at the same time supported by other activities.

The organization of teaching will be carried out using the following steps:

- **Lectures**: Theoretical activities carried out mainly through exposition by the teacher, where the theoretical supports of the subject are displayed, highlighting the fundamental, structuring them into topics and or sections, interrelating them.
- **Practice Sessions**: The teacher resolves practical problems or cases for demonstrative purposes. This type of teaching complements the theory shown in the lectures with practical aspects.
- **Laboratory Workshop**: Practical activities will be implemented in the computer room 1.1 simulation software structures (Wineva 7.0 and Abaqus.cae) with the presence and teacher mentoring.
- **Individual Tutorials**: Those carried out giving individual, personalized attention with a teacher from the department. Said tutorials may be in person or online.

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The design of the learning process is based on acquiring theoretical knowledge, and especially in learning how to use it in practical situations. Therefore the teaching sessions have been programmed to contain theory and practice through problem-solving examples, videos or physical models. At every time the participation of the student is encouraged, since the more the student does, the more they learn.

### 4.2.Learning tasks

| | |
|---|---|
| SPECIALIZATION IN BUSINESS<br><br>Programmed learning activities | The program offered to the student to help them achieve their target results is made up of the following activities:<br><br>Involves the active participation of the student, in a way that the results achieved in the learning process are developed, not taking away from those already set out, the activities are the following:<br><br>• Face-to-face generic activities:<br><br>Lectures: The theoretical concepts of the subject are explained and illustrative examples are developed as a support to the theory when necessary.<br><br>Practice Sessions: Problems and practical cases are carried out, complementary to the theoretical concepts studied.<br><br>Laboratory Workshop: This work is tutored by a teacher, in groups of no more than 20 students.<br><br>• Generic non-class activities:<br><br>Study and understanding of the theory taught in the lectures.<br><br>Understanding and assimilation of the problems and practical cases solved in the practical classes.<br><br>Preparation of seminars, solutions to proposed problems, etc.<br><br>Preparation of laboratory workshops, preparation of summaries and reports.<br><br>Preparation of the written tests for continuous assessment and final exams.<br><br>The subject has 6 ECTS credits, which represents 150 hours of student work in the subject during the trimester, in other words, 10 hours per week for 15 weeks of class.<br><br>A summary of a weekly timetable guide can be seen in the following table. These figures are obtained from the subject file in the Accreditation Report of the degree, taking into account the level of experimentation considered for the said subject is moderate. |

| Activity | Weekly school hours |
|---|---|
| Lectures | 3 |
| Laboratory Workshop | 1 |
| Other Activities | 6 |

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The activity program designed to learn this subject combines 1) class activities in the group and 2) non-presence activities:

1) The group activities will take place in the classroom or in a computer or materials laboratory, and there will be three kinds of sessions:

Lectures. These are theoretical and problem-solving classes, which allow to explain the concepts to the students and show them examples of strategies for solving practical cases. The whole group will be in the classroom. At the beginning of the theory sessions, the professor will present the aim of the activity in the context of the course. Theoretical classes will be intercalated with problem-solving sessions, where the professor will illustrate the application of the basic concepts and will give general guidelines for problem-solving. The problems used to work in this kind of session will be selected from a collection that will be given to the students. Participation of the student will be encouraged in by scheduling the program of the session so that the students can work on the problems beforehand.

Numerical Simulations and Tests in the Materials Laboratory. The laboratory courses will take place in the computer room and in the soil laboratory of the Regiment of Pontoneros (Monzalbarba). The lab classes will take two periods and their distribution will be based on the time available for every class-section. Before the activity, the students will have a script where the motivation of the activity and a detailed protocol of what to do will be explained. The students will be distributed in teams of two members and will hand in a report containing the results obtained in the lab (or via simulations), and the answers to questions posed in the script. The students may be tested at the end of the session to evaluate their accomplishment. The lab grade will be determined from the test grade together with the report grade. The laboratory classes are compulsory activities to successfully pass the subject and their evaluation will contribute to the final grade.

Tests. At the end of every topic, the last 30 minutes of class will be spent making a test with a dual objective. First, students will be allowed to measure their achievements by facing a problem of similar complexity to the ones in the final exam. Second, students will be made familiar with the correction criteria of the professor. These tests will be graded in a class by the students themselves or their classmates using a template prepared for the exercise. These grades will not contribute to the final evaluation.

2) The non-presence working hours will be invested in:

Autonomous work and study. The student is supposed to learn the basic theory, solve the collection of proposed exercises and hand-in the reports of the laboratory sessions. These activities are essential for the learning process of the student and to successfully comply with the evaluation activities. The best advice that can be given to the student is to work on the proposed exercises during the whole semester and seek help from colleagues or from a professor to solve problems that may have emerged.

Tutorials. The professor will be available during the semester for the students to come to the office and ask questions. In order to efficiently organize the tutorial sessions, the student will apply in class or by email for a tutorial session indicating their time availability. The professor will then agree with the student on a date, time and location for the tutorial session.

Observation and working closely with the student will allow orienting and steering the learning process adequately. The professor may give extra reinforcing work to the students if necessary; this extra work may consist of compulsory tutorials or solving additional exercises.

## 4.3.Syllabus

The course will address the following Topic s:

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Strength of Materials

- Topic 1: Introduction to Strength of Materials
    - Types of Structures, links and loads
    - Balance and GDH a Structure
    - Definition and types of internal efforts
    - Calculation and Representation Efforts diagrams
- Topic 2: Structure Design Rigid Knots
    - Laminating criteria: voltage Von- Mises.
    - Normal stress distribution in a section
    - Distribution of shear stress one section
    - Bending and Twisting problems in structures
- Topic 3: Structure Design Articulated Knots
    - Method for calculating knots structures
    - PTV method to calculate displacements
    - Buckling phenomenon
    - Calculation of the truss structure
- Topic 4: Calculation of displacements in structures
    - Theorems Mohr (Gyre y Displacements)
    - Virtual work (Gyre y Displacements)
    - Flexibility Method for Structural Analysis Hyperstatic
- Topic 5: Deformable Solid Mechanics: Stress-Strain
    - Deformable Solid Mechanics
    - Kinematics of Solid Deformable
    - Dynamics of Deformable Solid
    - Ratio behaviour
    - Thermoelastic behaviour

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**The contents of the course are organized according to the following index:**

- 1. Introduction to Mechanics of Materials
    - 1.1 Principles of Mechanics of Materials
    - 1.2 Theoretical Model of an Elastic Solid
    - 1.3 External and Internal Forces and Momenta
        - 1.3.1 Static Equilibrium and Elastic Equilibrium. The Method of Sections
        - 1.3.2 Internal Loadings. Normal and Shear Forces and Bending Moments and Torques
        - 1.3.3 External Loadings. External Forces, Reactions and Connections
        - 1.3.4 Statically Determinate and Indeterminate Systems
    - 1.4 Stress and Strain in Elastic Solids
        - 1.4.1 Concept of Stress and Strain
        - 1.4.2 Relationship between Stress and Strain. Stress-Strain Diagram
        - 1.4.3 Elastic/Linear Regime. Hooke's Law and Poisson's Ratio
    - 1.5 General Principles in Mechanics of Materials
    - 1.6 Allowable Stress and Load. Security Coefficient

        - 6.2.1. Stresses on Inclined Sections
        - 6.2.3. Transformation Equations
    - 6.3 Principal and Maximum Shear Stresses
    - 6.4 Mohr's Circle
        - 6.4.1. Mohr's Circle Construction
        - 6.4.2. Stresses on an Inclined Section
        - 6.4.3. Principal Stresses & Maximum Shear Stress
    - 6.5 Hooke's Law for Plane Stress
    - 6.6 Plane Stress

## 4.4.Course planning and calendar

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| weeks | WEEKLY PLANNING SEMESTER | |
|---|---|---|
| 1ª<br>2ª | Topic 1 | Exercise No. 1 Continuous Assessment |
| 3ª<br>4ª<br>5ª<br>6ª | Topic 2 | Exercise No. 2 Continuous Assessment<br>1st Practice with Wineva software (Topic 1 and 2)<br>1st Written Test ( Topic 1 and 2) |
| 7ª<br>8ª<br>9ª | Topic 3 | Exercise No. 3 Continuous Assessment<br>2nd Practice with software Wineva (Topic 3)<br>2nd Written Test (Topic 3) |
| 10ª<br>11ª<br>12ª | Topic 4 | Exercise No. 4 Continuous Assessment<br>3rd practice with software Wineva (Topic 4)<br>3rd Written Test (Topic 4) |
| 13ª<br>14ª<br>15ª | Topic 5 | Exercise No. 5 Continuous Assessment<br>4th Practice with Abaqus software (Topic 5)<br>4th Written Test (Topic 5) |

The weekly schedule of the subject will be published at http://www.eupla.unizar.es/asuntos-academicos/calendario-y-horarios

The dates of the global evaluation test (official calls) will be published at http://www.eupla.unizar.es/asuntos-academicos/examenes

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The schedule of classes, as well as the days of partial and global exams, can be checked on CUD's website (http://cud.unizar.es/calendarios)

Planning of lab courses will be noted to the students in class and/or through the Moodle platform: http://moodle2.unizar.es.

## 4.5.Bibliography and recommended resources

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**http://biblos.unizar.es/br/br_citas.php?codigo=30123&year=2019**

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http://biblos.unizar.es/br/br_citas.php?codigo=30123&year=2019

**Resources:**

| **Material** | **Format** |
|---|---|
| Topic theory notes<br>Topic problems | Paper/repository |
| Topic theory notes<br>Topic presentations<br>Topic problems<br>Related links | Digital/Moodle<br>E-Mail |
| Educational software Wineva.7.0 | Web page: ***wineva.upc.edu/esp/Download.php*** |