Universidad Zaragoza

Academic Year/course: 2022/23

30123 - Resistance of Materials

Syllabus Information

Academic Year: 2022/23
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
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.

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These approaches and objectives are in line with the following Sustainable Development Goals (SDGs) of the United Nations 2030 Agenda (https://www.un.org/sustainabledevelopment/es/), in such a way that the acquisition of the course learning outcomes provides training and competence to contribute to their achievement to some degree.

Goal 4: Quality Education

Goal 9: Build resilient infrastructure, promote sustainable industrialization and foster innovation

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.

Spezalization in Defence: This course contributes to the training in values of the Army Officers, providing technical skills and tools to respond to contingencies related to the design, sizing, materials selection and calculation of structural elements, which are needed by Army Officers to carry out their mission.

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 current labor market. Understanding the behavior of the different structural systems will be acquired, which is absolutely essential for the design of any set of interconnected elements that fulfill a structural function in a load bearing state.

3. Assessment (1st and 2nd call)

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

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The assessment must be understood as a continuous and individualized process throughout the entire teaching-learning period, prioritizing the capacities and abilities of each student, as well as their performance.

At the beginning of the course, the student will choose one of the following two assessment methodologies:

A) A continuous assessment system, which is carried out throughout the entire learning period. Characterized by the obligation to take and pass the practical tests, partial exams and academic tasks proposed in the subject, within the deadlines established for this purpose. In this case, the student does not have to take a final exam.

B) A global assessment test, showing the achievement of learning results, at the end of the teaching period. Characterized by not taking or not passing the practical tests, partial exams or academic work proposed in the subject. In this case, the student must compulsorily take the final exam.

Breakdown and content of each assessment system:

The continuous assessment system consists of three blocks that are explained below. The first condition is that the

1st Block: Continuous assessment exercises: The student will carry out a total of 5 continuous assessment exercises (one per chapter) on a compulsory basis in the continuous assessment system, which will be distributed throughout the course. Each exercise will be delivered to the student once the corresponding theory topics and exercises have been completed. The student will have a week to do it and deliver it to the teacher, since this activity is continuous and should not be delayed in time. The continuous assessment exercise will be very similar to the exercises carried out in class. In addition, the student will have tutorials to answer any questions about it. This activity will globally account for 40% of the final grade for the course. To take this grade into account the student must meet two requeriments:

- 1st They will have to deliver all the exercises within the period given by the teacher. Otherwise, this activity will be considered as a fail (except for properly justified major cause).
- 2nd They will have to obtain a minimum of 3.0 in each exercise. And you must obtain a minimum grade of 4.0 with all the exercises included. If not, this activity will be considered as a fail.

2nd Block: Written tests for continuous assessment. The student will take a total of four compulsory written tests in the continuous assessment system, which will be distributed throughout the course. These tests will include theoretical questions and exercises on the corresponding topics. The duration of the test will be a minimum of two hours of classes and a maximum of three, depending on the case. This activity will globally account for 50% of the final grade of the course, to take this mark into account, the student must fulfill two requirements:

- 1st They will have to turn up in all the tests in the date given by the professor. Otherwise, this activity will be considered as a fail (except for properly justified major cause).
- 2nd They will have to obtain a minimum of 3.0 in each test. And they must obtain, including all the tests, a minimum grade of 4.0. If not, this activity will be considered as a fail.

3rd Block: Computer-Assisted Practices. The student will carry out two compulsory practice sessions in the continuous assessment system, which will be distributed throughout the course, according to the planning chart. This activity will globally account for 10% of the final grade for the course, to take this grade into account the student must meet two requirements:

- 1st They will have to attend all practice sessions on the date given by the teacher. Otherwise, this activity will be considered as a fail (except for properly justified major cause).
- 2nd They will have to obtain a minimum of 3.0 in each practice. And they must obtain a minimum grade of 4.0 including all the practices. If not, this activity will be considered as a fail.

Prior to the first call, the teacher will notify each student whether or not they have passed the subject depending on the use of the continuous assessment system, based on the sum of the scores obtained in the different activities carried out throughout it. according to the formulation:

Final mark of the subject in THE first call = 50% A + 40% B + 10% C

A = Average grade of written tests
B = Average grade of exercises
C = Average mark of practice task

Thus, they must obtain a minimum grade of 5.0 to pass the course, fulfilling all the above mentioned and explained requirements. The students who have passed the subject in this way, will be allowed to increase their grade on the first call (never to lower it).

Global Test: In case of not passing with the previous system, the student will have two additional calls (June and September) with a global assessment test. This test will be unique with theory and exercises representative of the entire syllabus of the subject contributing 100% to the final grade of the course.

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Evaluation activities

The student must demonstrate that they have achieved the expected learning outcomes and that they know and use the fundamental laws of Materials Resistance to solve practical problems, using appropriate scientific and mathematical language. It will be necessary to evaluate this knowledge, but above all its implementation. For this, the following evaluation activities will be carried out, grouped into two evaluation systems:

1. Continuous evaluation system:

It will take place throughout the semester. Its purpose is to measure the degree of assimilation of the subjects taught. It will have three parts:

1.1. Continuous Assessment Tests (PEC, "Pruebas de Evaluación Continua" in Spanish):

Throughout the semester, 3 written tests will be carried out on the contents of the course, which will consist of solving problems and theoretical and practical questions. The PECs will be weighted according to their importance, and the mean

will have a weight of 80% on the final score.

To pass the subject through continuous assessment, the weighted average of the PEC must be greater than or equal to 4.0.

1.2. Practices (NP, " Nota Prácticas" in Spanish):

There will be 2 practices throughout the course. They will consist of solving Materials Resistance problems. The students will be organized in groups of 2-3 students. The NP are weighted according to the level of difficulty of the same and the estimated effort to be made by the student.

To pass the subject through continuous assessment, the weighted average of the practices must be greater than or equal to 4.0.

STUDENT OPTS AND MAY APPROVE BY CONTINUOUS EVALUATION IF:

PEC >= 4

NP >= 4

Will obtain a final score by continuous evaluation NF_EC:

$$NF\_EC = [0,3\times PEC_1 + 0,3\times PEC_2 + 0,2\times PEC_3] + [0,05\times NP_1 + 0,15\times NP_2]$$

$$NF\_EC = 0,8\times PEC + 0,2\times NP$$

The student will pass the subject if NF_EC >= 5

2. Global evaluation system:

First call:

The students who do not pass the subject by continuous assessment or who would like to improve their grade, will have the right to take the Global Test set in the academic calendar, prevailing, in any case, the best of both grades. This global test will be equivalent to the continuous assessment test described and will have the 100% weight in the final grade. This test will cover the contents of all the taught material, including the practices. It will consist of solving problems and theoretical-practical questions at the end of the semester to measure the final learning result. To pass the subject, the student?s final grade must be equal to or greater than 5.

Second call:

The students who do not pass the subject in the first call may take the Global Test set in the academic calendar for the second call. The global test will cover the contents of all the taught material and will include questions related to the practices of the subject. To pass the course the final grade must be equal to or greater than 5.0.

4. Methodology, learning tasks, syllabus and resources

4.1. Methodological overview

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The approach, methodology and assessment of this guide are intended to be the same for any teaching scenarios. They will be adapted to the socialhealth situation at any particular time, as well as to the instructions given by the authorities concerned.

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.

The approach, methodology and assessment of this course is prepared to be equivalent in any teaching scenario. It will be

adjusted to the socio-sanitary conditions of each moment, as well as to the indications given by the competent authorities.

4.2. Learning tasks

SPECIALIZATION IN BUSINESS Programmed learning activities	The program offered to the student to help them achieve their target results is made up of the following activities: 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: • Face-to-face generic activities: Lectures: The theoretical concepts of the subject are explained and illustrative examples are developed as a support to the theory when necessary. Practice Sessions: Problems and practical cases are carried out, complementary to the theoretical concepts studied. Laboratory Workshop: This work is tutored by a teacher, in groups of no more than 20 students. • Generic non-class activities: Study and understanding of the theory taught in the lectures. Understanding and assimilation of the problems and practical cases solved in the practical classes. Preparation of seminars, solutions to proposed problems, etc. Preparation of laboratory workshops, preparation of summaries and reports. Preparation of the written tests for continuous assessment and final exams. 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. 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, and there will be two 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.

Follow-up tests. At the end of the first four topics (of six that make up the syllabus), part of one of the theoretical-practical classes will be dedicated to carry out a follow-up test to acquire knowledge (Continuous Assessment Tests).

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.

Simulation practices. There will be 2 practices throughout the course. They will consist of solving Material Resistance problems using the Python programming language or alternative tools. The students will be organized in groups of 2-3 students. The practices are weighted according to the level of difficulty of the same and the estimated effort to be made by the student. Associated with the last practice there will be a defense in class.

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
- 1.4 Stress and Strain in Elastic Solids
- 1.5 General Principles in Mechanics of Materials
- 1.6 Allowable Stress and Load. Security Coefficient
- 1.7 Strength Criteria. Equivalent Stress

2. Axially Loaded Members

- 2.1 Uniaxial Traction and Compression: Stress and Strain
- 2.2 Strain Energy
- 2.3 Statically Indeterminate Structures

3. Shear force and Bending of Beams

- 4.1 Introduction
- 4.2 Pure Bending: Stress Analysis

- 4.3 Simple Bending: Stress Analysis
- 4.4 Deflection of Beams
- 4.5 Application in Simple Cases
- 4.6 Method of Superposition
- 4.7 Composite Beams
- 4.8 Statically Indeterminate Beams

4. Torsion

4.1 Introduction
4.2 Torsional Deformation of a Circular Shaft
4.3 Power Transmission
4.4 Statically Indeterminate Torque-Loaded Members

5. Buckling

- 5.1 Introduction. Strength, Stiffness and Stability
- 5.2 Buckling of Columns with Pinned Ends
- 5.3 Buckling of Columns with other Support Conditions
- 5.4 Critical Stress

4.4. Course planning and calendar

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weeks	WEEKLY PLANNING SEMESTER	
1ª 2ª	Topic 1	Exercise No. 1 Continuous Assessment
3ª 4ª 5ª 6ª	Topic 2	Exercise No. 2 Continuous Assessment 1st Practice with Wineva software (Topic 1 and 2) 1st Written Test (Topic 1 and 2)
7ª 8ª 9ª	Topic 3	Exercise No. 3 Continuous Assessment 2nd Practice with software Wineva (Topic 3) 2nd Written Test (Topic 3)
10ª 11ª 12ª	Topic 4	Exercise No. 4 Continuous Assessment 3rd practice with software Wineva (Topic 4) 3rd Written Test (Topic 4)
13ª 14ª 15ª	Topic 5	Exercise No. 5 Continuous Assessment 4th Practice with Abaqus software (Topic 5) 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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Bibliography available at: http://psfunizar10.unizar.es/br13/egAsignaturas.php?codigo=30123

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http://psfunizar10.unizar.es/br13/egAsignaturas.php?codigo=30123

Resources:

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