

Course guide

240228 - 240AU102 - Structural Analysis

Last modified: 16/05/2023

Unit in charge: Barcelona School of Industrial Engineering
Teaching unit: 737 - RMEE - Department of Strength of Materials and Structural Engineering.

Degree: MASTER'S DEGREE IN AUTOMOTIVE ENGINEERING (Syllabus 2019). (Optional subject).

Academic year: 2023 **ECTS Credits:** 4.5 **Languages:** Spanish

LECTURER

Coordinating lecturer: JULIÁN ARNALDO ÁVILA DÍAZ

Others: Segon quadrimestre:
JULIÁN ARNALDO ÁVILA DÍAZ - Grup: 10
ORIOL BOVÉ TOUS - Grup: 10
MIQUEL CASAFONT RIBERA - Grup: 10

PRIOR SKILLS

knowledge of continuum mechanics and strenght of materials at bachelor level
Minimum level of knowledge of Spanish: B2

REQUIREMENTS

theory of elasticity and strength of materials

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:

CEAU15. (ENG) Realitzar, presentar i defensar un exercici original realitzat individualment davant d'un tribunal universitari, consistent en un projecte integral d'Enginyeria d'Automoció de naturalesa professional en què se sintetitzin les competències adquirides en els ensenyaments.

CEAU14. (ENG) Seleccionar i utilitzar les eines adequades per dissenyar elements d'automoció en resposta a les especificacions tècniques donades.

CEAU 1. (ENG) Realitzar models d'enginyeria, aplicar mètodes innovadors en la resolució de problemes i aplicacions informàtiques adequades, per al disseny, simulació, optimització i control de processos i sistemes.

Generical:

CGAU 4. Be able to conduct research, development and innovation in relation to automotive technology.

CGAU11. Develop independent learning skills to maintain and enhance the powers of Automotive Engineering, to allow the continued development of the profession.

CGAU 7. Integrate knowledge and handle complexity, making judgments and decisions, from incomplete or limited information, including reflections on the social and ethical responsibilities of professional practice

Transversal:

CTAU3. (ENG) TREBALL EN EQUIP: Ser capaç de treballar com a membre d'un equip interdisciplinari, ja sigui com un membre més, o realitzant tasques de direcció, amb la finalitat de contribuir a desenvolupar projectes amb pragmatisme i sentit de la responsabilitat, assumint compromisos tenint en compte els recursos disponibles.

Basic:

CB 9. (ENG) Que els estudiants sàpiguen comunicar les seves conclusions i coneixements (i darrers raonaments que els sustentin), a públics especialitzats i no especialitzats de manera clara i sense ambigüitats.

CB 7. (ENG) Que els estudiants sàpiguen aplicar els coneixements adquirits i la seva capacitat de resolució de problemes en entorns nous o poc coneguts dintre de contextos més amplis (o multidisciplinars) relacionats amb la seva àrea d'estudi.

TEACHING METHODOLOGY

a) 40.5 hours of face-to-face sessions, consisting of lectures, problems and 3 practical sessions for the resolution of simple cases. (in a working group)

b) Short exercises solved outside the classroom (individual)

c) Resolution of a practical case chosen by the students themselves (in a working group)

The working groups to carry out activities a) and c) will be formed by between three and five students, will be defined at the beginning of the course and will be maintained until the end.

During the spring term of the 2020-2021 academic year, and as a consequence of the health crisis caused by the Covid19 , the teaching methodology will present the following changes:

Theory and problem classes will be held online using Google meet, maintaining both the content and the rest of the activities planned for the course, including deliverable and practical exercises. Practices 1 and 2 will be carried out online, and practice nº 3 will be carried out in person unless the health situation prevents it, in which case it will be replaced by a work on the same content.

LEARNING OBJECTIVES OF THE SUBJECT

To review, expand and consolidate the foundations of structural analysis, specifying it to the most characteristic phenomena and typologies of structures and components in the automobile industry, in order to conceive and/or optimise its design.

- To review the basic concepts of continuum mechanics.
- To review and extend the knowledge on prismatic parts.
- To review and extend the knowledge about plates and shells.
- Introduction to numerical simulation using the method of finite elements.
- Methods of experimental structural analysis.
- Fatigue and durability of components, systems and structures.

STUDY LOAD

Type	Hours	Percentage
Self study	72,0	64.00
Hours small group	13,5	12.00
Hours large group	27,0	24.00

Total learning time: 112.5 h

CONTENTS

Structural analysis in automotive engineering. Structural typologies.

Description:

Presentation of the role of structural analysis in the design and development of a new vehicle. Main structural typologies.

Specific objectives:

Introduce the various applications of automotive structural analysis. Presentation of the main structural typologies used in the automotive industry.

Related activities:

Synthesis and search for additional information.

Full-or-part-time: 3h 30m

Theory classes: 1h 30m

Self study : 2h

Fundamentals of Continuum Mechanics.

Description:

Review of the basic concepts applicable to structural analysis in automotive: stresses, strains, constitutive equations and strength criteria.

Agenda:

- 1.1. Introduction to the mechanics of the continuous medium.
- 1.2. State of strain.
- 1.3. State of stress.
- 1.4. Constitutive equations.
- 1.5. Failure theories.

Specific objectives:

Establish a solid foundation on the physical concepts that support structural analysis in automotion.

Related activities:

Resolution of application exercises.

Full-or-part-time: 15h 30m

Theory classes: 4h

Practical classes: 1h 30m

Self study : 10h

Fundamentals of strength of materials: Prismatic parts

Description:

Starting hypothesis, different modes of load, buckling and free vibrations in beams.

Topic:

- 2.1. Introduction to strength of materials: Prismatic parts.
- 2.2. Normal stress.
- 2.3. Bending.
- 2.4. Torsion.
- 2.5. Joints
- 2.6. Stability, critical loads and buckling modes
- 2.7. Introduction to dynamic analysis. Free vibrations of prismatic parts.

Specific objectives:

Review and consolidate the basic concepts of strength of materials and extend them with complementary topics.

Related activities:

Resolution of application exercises

Full-or-part-time: 15h 30m

Theory classes: 4h

Practical classes: 1h 30m

Self study : 10h

plate and shell foundations

Description:

Starting assumptions, different modes of loading, thick and thin plates, shells and vessels, buckling and denting, free vibrations.

Topics:

- 3.1. Small thickness plates.
- 3.2. Very thick plates.
- 3.3. Shells and vessels.
- 3.4. Stability, critical loads and buckling modes.
- 3.5. Plate vibrations, frequencies and eigenmodes.

Specific objectives:

Review and consolidate the concepts and expand them with complementary themes.

Related activities:

Resolution of application exercises.

Full-or-part-time: 11h

Theory classes: 3h

Practical classes: 1h

Self study : 7h

Introduction to the finite element method.

Description:

Introduce the finite element method as the technological basis for the simulation of structural behaviour. The theoretical presentation will be complemented with the technological and practical aspects that structural analysis engineers will face in the exercise of their work.

Agenda:

Fundamentals of the finite element method.

4.2. Practical aspects.

4.3. Case study.

4.4. Stability analysis, critical loads and buckling modes. Stress stiffening.

4.5. Frequency and eigenmodes analysis.

Specific objectives:

Understand continuous structural systems as an extension of discrete systems. Present the concepts of interpolation, discretization and the general approach of the method for solving elastic and linear problems: static case, linear buckling, stress stiffening and eigenfrequencies and modes of vibration. The numerical techniques used, the definition of the numerical models, and the interpretation of the results will be included.

Related activities:

Application exercise. 2 simulation practices using the FEM

Full-or-part-time: 33h

Theory classes: 8h

Laboratory classes: 4h

Self study : 21h

Fatigue and durability

Description:

The physical phenomenon. Characterization of materials. Factors that modify resistance. Life prediction, accumulated damage, cycle counting. Numerical methods. Particularities of the automotive sector.

Topics:

5.1 Physical foundations.

5.2 Approaches to durability analysis: S-N curves and local strain method.

5.3. Applications from the numerical simulation.

5.4. Fatigue of welded and bolted joints.

5.5. Design recommendations.

Specific objectives:

learn to calculate structural elements and components to infinite life. Make fatigue life predictions. Proper use of analytical and numerical calculation models.

Related activities:

Resolution of application exercises.

Full-or-part-time: 17h

Theory classes: 4h 30m

Practical classes: 1h 30m

Self study : 11h

Experimental structural analysis

Description:

Presentation of the various types of tests on physical prototypes related to structural analysis.

Agenda:

- 6.1 Introduction.
- 6.2. Electrical extensometry.
- 6.3. Introduction to the experimental modal analysis.
- 6.4. Fatigue tests.

Specific objectives:

To ensure a holistic view of the structural analysis process that ensures an adequate balance between numerical simulation and experimentation. The techniques of extensometry, modal analysis and fatigue testing will be presented.

Related activities:

Application exercises. 1 practical session: extensometry and viewing of various test facilities.

Full-or-part-time: 17h

Theory classes: 4h

Laboratory classes: 2h

Self study : 11h

GRADING SYSTEM

There are two types of evaluation: (1) continuous and (2) special.

Continuous evaluation:

Continuous assessment is intended for students who are able to follow the course on a regular basis. The teaching methodology has been designed for this modality.

The elements that are taken into account for the evaluation are (1) partial test, (2) presentations of exercises and practices, (3) final presentation of the coursework. (4) final test.

With the 4 elements above, 4 marks are constructed: (NEP) partial test, (NEC) continuous assessment grade that incorporates the grades of the exercises submitted and the practices, (NEF) final test, and (NTC) grade of the coursework and presentation of the same. The final grade (NF) is obtained by weighting the four elements above as follows:

Grading system: $NF = 0.2 \cdot NEP + 0.2 \cdot NEF + 0.2 \cdot NEC + 0.4 \cdot NTC$

If the course is suspended, a re-evaluation test can be taken.

In this case, the score of the re-evaluation exam (NER) will replace the scores of the final exam (NEF) and partial exam (NEP) in the calculation of the final score:

Grading system: $NF = 0.4 \cdot NER + 0.4 \cdot NTC + 0.2 \cdot NEC$

Special evaluation:

The special evaluation is intended for students who, because of circumstances, are usually unable to attend class. This modality excludes the previous one, and mixed approaches are not possible. In order to adhere to it, it must be communicated in writing at the beginning of the course.

NOTE: The Master's Degree in Automotive Studies is a face-to-face course, so no distance support will be available for the non-classroom development of the subject.

Students in this situation must take the partial (NEP) and final (NEF) exams, carry out and hand in all the work and exercises proposed during the course, including the 2 finite element practices that will be carried out autonomously by the student (NEC), and carry out and hand in the course work individually (NTC) although this may have a lesser scope, which must be previously approved by the course coordinator.

The re-evaluation process will be identical to continuous assessment.

$NF = 0.2 \cdot NEP + 0.2 \cdot NEF + 0.2 \cdot NEC + 0.4 \cdot NTC$



EXAMINATION RULES.

- a) Partial examination: This is a written conceptual examination, the aim of which is to ensure that the theoretical concepts underlying the practical part of the course have been assimilated. A form (one A4 sheet) will be allowed to be used for this examination. The corresponding grade (NEP) will include the evaluation of the case study proposal submitted for the course work which will have a weight of 30% on the total NEP grade.
- b) Final Exam: This is a written conceptual exam, the objective of which is to ensure that the theoretical concepts underlying the practical part of the course have been assimilated, excluding what has already been examined in the partial exam. To take it, the use of a form will be allowed (a DIN A4 sheet)
- c) Continuous evaluation: throughout the course, three deliverable exercises will be proposed to be solved in teams outside the classroom. Likewise, three practices will be carried out (2 of simulation by means of finite elements and one of experimental mechanics) also in teams. Each practice must be accompanied by the delivery of the corresponding report.
- d) Course work: Each work group will have to identify and solve a case study during the course. A first delivery will be made with the case definition report, which will be evaluated together with the partial examination, and a second delivery with the report of the complete work, which will be presented orally to be evaluated during the last session of the course.
- e) Re-evaluation Examination: It will be equivalent to the examinations it replaces.