ANX-PR/CL/001-01

LEARNING GUIDE

SUBJECT

43000609 - Integridad Estructural

DEGREE PROGRAMME

04AN - Master Universitario En Ingenieria De Materiales

ACADEMIC YEAR & SEMESTER

2023/24 - Semester 2

Index

Learning guide

1. Description

1.1. Subject details

Name of the subject	43000609 - Integridad Estructural
No of credits	3 ECTS
Type	Optional
Academic year ot the programme	First year
Semester of tuition	Semester 2
Tuition period	February-June
Tuition languages	English
Degree programme	04AN - Master Universitario en Ingenieria de Materiales
Centre	04 - Escuela Tecnica Superior De Ingenieros De Caminos, Canales Y Puertos
Academic year	2023-24

2. Faculty

2.1. Faculty members with subject teaching role

Name and surname	Office/Room	Email	Tutoring hours *
Rafael Sancho Cadenas		rafael.sancho@upm.es	Sin horario. Under students request by e-mail
David Angel Cendon Franco (Subject coordinator)		david.cendon.franco@upm.es	Sin horario. Under students request by e-mail

* The tutoring schedule is indicative and subject to possible changes. Please check tutoring times with the faculty member in charge.

3. Prior knowledge recommended to take the subject

3.1. Recommended (passed) subjects

The subject - recommended (passed), are not defined.

3.2. Other recommended learning outcomes

- Strength of Materials

- Elasticity and Plastic behaviour of materials

4. Skills and learning outcomes *

4.1. Skills to be learned

CE1 - Capacidad para aplicar los fundamentos científicos del comportamiento físico y químico de los materiales para relacionar causalmente sus propiedades fundamentales físicas y químicas con su comportamiento macroscópico y el de los productos con ellos realizados / Ability to apply the scientific foundations of the physical and chemical behavior of materials to correlate their fundamental physical and chemical properties with their macroscopic behavior and that of the products made with them.

CE3 - Capacidad de diseñar, modelizar, evaluar, seleccionar, fabricar y utilizar materiales con propiedades específicas (estructurales y funcionales) para satisfa

CE6 - Capacidad para controlar y modificar los mecanismos físicos y químicos que determinan las fases del ciclo de vida de los materiales, su durabilidad y su incidencia en el medioambiente con el fin de poder evaluar, controlar y mejorar la seguridad, durabilidad e integridad estructural de los materiales y los componentes fabricados con ellos / Ability to control and modify the physical and chemical mechanisms that determine the phases of the life cycle of materials, their durability and their impact on the environment in order to be able to evaluate, control and improve the safety, durability and structural integrity of materials and components made from them

CE7 - Manejo de herramientas de simulación numérica para diseño y análisis de materiales, desde la escala microscópica a la macroscópica / Management of numerical simulation tools for design and analysis of materials, from the microscopic to the macroscopic scale

CE8 - Aplicación del método científico para la resolución de problemas y la generación de conocimiento /

Application of the scientific method to solve problems and generate knowledge

CG1 - Uso de la lengua inglesa: Los alumnos son capaces de transmitir conocimientos y expresar ideas y argumentos de manera clara, rigurosa y convincente, tanto de forma oral como escrita, adaptándose a las características de la situación y de la audiencia / Use of the English Language: Students are able to transmit knowledge and express ideas and arguments in a clear, rigorous and convincing manner, both orally and in writing, adapting to the characteristics of the situation and the audience .

CG8 - Resolución de problemas: Los estudiantes son capaces de reconocer, describir, organizar y analizar los elementos constitutivos de un problema para idear estrategias que permitan obtener, de forma razonada, una solución contrastada y acorde a ciertos criterios preestablecidos / Problem solving: Students are able to recognize, describe, organize and analyze the constitutive elements of a problem to devise strategies that allow obtaining, in a reasoned way, a contrasting solution and according to certain pre-established criteria.

4.2. Learning outcomes

RA8 - RA32 - Conocer, comprender y saber aplicar los fundamentos científicos del comportamiento de los materiales

RA2 - Ser capaz de aprender y actualizar autónomamente nuevos conocimientos y técnicas

RA3 - Conocer, comprender y saber aplicar las bases de la ciencia y del método científico

* The Learning Guides should reflect the Skills and Learning Outcomes in the same way as indicated in the Degree Verification Memory. For this reason, they have not been translated into English and appear in Spanish.

5. Brief description of the subject and syllabus

5.1. Brief description of the subject

This course provides an approach to classical Fracture Mechanics and, especially, to the fracture of two-dimensional solids with linear-elastic behavior. Additionally, practical aspects of elasto-plastic fracture are also introduced, with special emphasis on the J-Integral and the use of failure assessment diagrams. In the field of subcritical crack propagation, fatigue propagation is introduced, as well as stress corrosion cracking. Finally, it should be highlighted that this course gives special relevance to the use of numerical methods, hence a total of 4 finite element practical exercises will be proposed to the students.

5.2. Syllabus

1. Chapter 1. The Global Approach to Fracture
   1.1. Introduction. The Energy Release Rate, G
   1.2. The Specific Fracture Energy, R. Measurement of R.
2. Chapter 2. Local Approach to Fracture
   2.1. The Stress Intensity Factor
   2.2. Fracture Toughness. Measurement of the Fracture Toughness
3. Chapter 3. Mixed mode crack propagation
   3.1. Main theories for crack propagation under mixed mode
4. Chapter 4. Subcritical crack propagation
   4.1. Stress life approach
   4.2. Strain life approach
   4.3. Stress corrosion cracking
5. Chapter 5. Elasto-plastic fracture
   5.1. Plasticity at the crack tip
   5.2. J-Integral
   5.3. Failure assessment diagrams

6. Schedule

6.1. Subject schedule*

Week	Classroom activities	Laboratory activities	Distant / On-line	Assessment activities
1	**Introduction and objectives. Lecturers. History of Fracture Mechanics.** Duration: 00:45 Lecture **The Global Approach: the energy balance. The Energy Release Rate Concept** Duration: 01:00 Problem-solving class			
2	**The Global Apprach: Calculation of the Energy Release Rate (G). R curves.** Duration: 01:00 Lecture **Numerical methods applied to Fracture Mechanics. Instalation of FRANC2D and CASCA.** Duration: 00:45 Lecture			
3	**The global approach: practical exercises** Duration: 01:45 Problem-solving class			
4	**Numerical exercise 1: presentation and explanation of the case** Duration: 00:45 Lecture			**Test about the global approach** Online test Continuous assessment Presential Duration: 01:00
5	**The local approach: Introduction** Duration: 00:45 Lecture **The local approach: Claculation of ths Stress Intensity Factor** Duration: 01:00 Lecture			
6	**The local approach: Measurement of the Fracture Toughness** Duration: 01:00 Lecture **The local approach: practical exercises** Duration: 00:45 Problem-solving class			**Report of numerical exercise 1** Individual work Continuous assessment Not Presential Duration: 04:00

7	**The local approach: Practical exercises** Duration: 01:45 Problem-solving class			
8	**Numerical exercise 2: presentation and explanation of the case.** Duration: 00:45 Lecture			**Test about the local approach** Online test Continuous assessment Presential Duration: 01:00
9	**Mixed mode crack propagation** Duration: 01:00 Lecture **Numerical exercise 3: presentation and explanation of the case.** Duration: 00:45 Lecture			
10	**Introduction to subcritical crack propagation** Duration: 00:45 Lecture **Fatigue crack propagation. Stress life approach. SN curves. Paris Law.** Duration: 01:00 Lecture			**Report of numerical exercise 2** Individual work Continuous assessment Not Presential Duration: 04:00
11	**Fatigue crack propagation. Variable amplitude. Strain life approach** Duration: 01:00 Lecture **Stress corrosion cracking** Duration: 01:00 Lecture			**Report of numerical exercise 3** Individual work Continuous assessment Not Presential Duration: 04:00
12	**Practical exercises of fatigue** Duration: 01:45 Problem-solving class			
13	**Numerical exercise 4: fatigue crack propagation** Duration: 00:45 Lecture			**Test of subcritical crack propagation** Online test Continuous assessment Presential Duration: 01:00
14	**Elastoplastic fracture. Plasticity at the crack tip. Equivalent crack models** Duration: 01:00 Lecture **The J-Integral** Duration: 00:45 Lecture			
15	**Failure assessment diagrams** Duration: 00:45 Lecture **Practical exercises of elasto-plastic fracture** Duration: 01:00 Problem-solving class			**Report of numerical exercise 4** Individual work Continuous assessment Not Presential Duration: 04:00

16	**Resolution of class tests 1, 2, 3 and 4** Duration: 00:45 Lecture			**Test of elasto-plastic fracture** Online test Continuous assessment Presential Duration: 01:00
17				**Final exam and ordinary exam** Written test Continuous assessment and final examination Presential Duration: 01:45 **Extraordinary exam** Written test Final examination Presential Duration: 01:45

Depending on the programme study plan, total values will be calculated according to the ECTS credit unit as 26/27 hours of student face-to-face contact and independent study time.

* The schedule is based on an a priori planning of the subject; it might be modified during the academic year, especially considering the COVID19 evolution.

7. Activities and assessment criteria

7.1. Assessment activities

7.1.1. Assessment

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
4	Test about the global approach	Online test	Face-to-face	01:00	7.5%	0 / 10	CG8 CE1 CE3 CE6 CE8
6	Report of numerical exercise 1	Individual work	No Presential	04:00	7.5%	0 / 10	CG1 CE3 CE7
8	Test about the local approach	Online test	Face-to-face	01:00	7.5%	0 / 10	CG8 CE1 CE6 CE8
10	Report of numerical exercise 2	Individual work	No Presential	04:00	7.5%	0 / 10	CG1 CE3 CE7
11	Report of numerical exercise 3	Individual work	No Presential	04:00	7.5%	0 / 10	CG1 CE3 CE7
13	Test of subcritical crack propagation	Online test	Face-to-face	01:00	7.5%	0 / 10	CG8 CE1 CE3 CE6 CE8
15	Report of numerical exercise 4	Individual work	No Presential	04:00	7.5%	0 / 10	CG1 CE3 CE7
16	Test of elasto-plastic fracture	Online test	Face-to-face	01:00	7.5%	0 / 10	CG8 CE1 CE3 CE6 CE8
17	Final exam and ordinary exam	Written test	Face-to-face	01:45	40%	0 / 10	CG1 CG8 CE1 CE3 CE6 CE7 CE8

7.1.2. Global examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
17	Final exam and ordinary exam	Written test	Face-to-face	01:45	40%	0 / 10	CG1 CG8 CE1 CE3 CE6 CE7 CE8
17	Extraordinary exam	Written test	Face-to-face	01:45	100%	5 / 10	CG1 CG8 CE1 CE3 CE6 CE7 CE8

7.1.3. Referred (re-sit) examination

No se ha definido la evaluación extraordinaria.

7.2. Assessment criteria

Teaching methodology:

The teacher will present the concepts necessary for understanding the contents of the subject, accompanied by examples and practical exercises to develop the scientific and technical capabilities of the student. Student participation will be encouraged, inviting him to discuss during lectures.

During lectures of practical exercises the knowledge acquired will be applied to the resolution of practical problems, so that the student gets used in approaching and solving problems similar to those that will be found in real life engineering.

Laboratory practices will not be carried out in this subject.

Assessment criteria:

*PROGRESSIVE ASSESSMENT

If this option ('progressive assessment') is chosen, the final mark will consist of the combination of 4 items: class attendance and attitude, test classes, numerical exercises and final exam.

Final mark = PE1 (5%) + PE2 (30%) + PE3 (30%) + PE4 (40%)

PE1: class attendance and class attitude

PE2: class tests

PE3: numerical exercises

PE4: maximum mark between 'final exam' and 'class tests'

Pass mark: 0.05*PE1 + 0.3*PE2 + 0.3*PE3 + 0.4*PE4 >=5 or PE4>=5

It can be observed that the sum of percentages exceeds 100. This is due to the 'extra' character of the class attendance and class attitude item: the students are not forced to attend all lectures but their presence will be rewarded with 0.5/10 points.

Each class test consists of a series of theoretical and practical exercises whose solution will be provided through the Moodle webpage.

The numerical exercises will be evaluated through the corresponding individual reports that each student must provide at the deadline date set by the professor.

The final exam will have a similar structure than the class tests, but in this case the student will have to provide also the notes and operations made to reach the final answers.

*SINGLE EXAM ASSESSMENT

Final exam (ordinary)

The ordinary final exam will be the same than the final exam (PE4). This is the reason why the final exam belongs to the continuous assessment and to the single exam assessment. However, if the option of single exam is chosen, this will be the only item to be considered in the final mark.

FE: ordinary final exam

Pass mark: FE>=5 or PE4>=5

*Final exam (extraordinary)

Those students that were unable to pass the subject through continuous assessment or through the ordinary exam can take the extraordinary final exam. In this case, the final mark will be obtained in a single exam (EE). This will be the only item considered in the final mark.

EE: extraordinary final exam

Pass mark: EE >= 5

8. Teaching resources

8.1. Teaching resources for the subject

Name	Type	Notes
Fracture Mechanics	Bibliography	Author: T.L. Anderson Editorial: CRC Press, London
The Practical Use of Fracture Mechanics	Bibliography	Author: D. Broek Editorial: Kluwer Academic Publisher, Dordrecht
Mecánica de la Fractura	Bibliography	Author: M. Elices Editorial: Servicio de Publicaciones de la ETSI de Caminos, Canales y Puertos, Madrid