



## Teaching Guide

| Teaching Guide           |                                                                                                                                                                                                                                                                                                                                                          |        |                                           |           |
|--------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-------------------------------------------|-----------|
| Identifying Data         |                                                                                                                                                                                                                                                                                                                                                          |        |                                           | 2020/21   |
| Subject (*)              | Degradation of Metals                                                                                                                                                                                                                                                                                                                                    |        | Code                                      | 730497229 |
| Study programme          | Mestrado Universitario en Enxeñaría Industrial (plan 2018)                                                                                                                                                                                                                                                                                               |        |                                           |           |
| Descriptors              |                                                                                                                                                                                                                                                                                                                                                          |        |                                           |           |
| Cycle                    | Period                                                                                                                                                                                                                                                                                                                                                   | Year   | Type                                      | Credits   |
| Official Master's Degree | 1st four-month period                                                                                                                                                                                                                                                                                                                                    | Second | Optional                                  | 4.5       |
| Language                 | Spanish                                                                                                                                                                                                                                                                                                                                                  |        |                                           |           |
| Teaching method          | Face-to-face                                                                                                                                                                                                                                                                                                                                             |        |                                           |           |
| Prerequisites            |                                                                                                                                                                                                                                                                                                                                                          |        |                                           |           |
| Department               | Enxeñaría Naval e Industrial                                                                                                                                                                                                                                                                                                                             |        |                                           |           |
| Coordinador              | Mier Buenhombre, Jose Luis                                                                                                                                                                                                                                                                                                                               | E-mail | jose.mier@udc.es                          |           |
| Lecturers                | Camba Fabal, Carolina<br>Mier Buenhombre, Jose Luis                                                                                                                                                                                                                                                                                                      | E-mail | carolina.camba@udc.es<br>jose.mier@udc.es |           |
| Web                      |                                                                                                                                                                                                                                                                                                                                                          |        |                                           |           |
| General description      | Nesta materia estúdase a degradación superficial de materiais metálicos por corrosión e desgaste. Tras unha introdución dos fundamentos básicos profundarase nos distintos mecanismos de ambos os fenómenos e nos modos de protexer o metal dos seus efectos.                                                                                            |        |                                           |           |
| Contingency plan         | 1. Modifications to the contents<br><br>2. Methodologies<br>*Teaching methodologies that are maintained<br><br>*Teaching methodologies that are modified<br><br>3. Mechanisms for personalized attention to students<br><br>4. Modifications in the evaluation<br><br>*Evaluation observations:<br><br>5. Modifications to the bibliography or webgraphy |        |                                           |           |

## Study programme competences

| Code | Study programme competences                                                                                                                                                                                                                                                         |
|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| B1   | CB6 - Possess and understand knowledge that provides a basis or opportunity to be original in the development and / or application of ideas, often in a research context.                                                                                                           |
| B2   | CB7 - That students know how to apply the knowledge acquired and their ability to solve problems in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their area of study.                                                                   |
| B3   | CB8 - That students are able to integrate knowledge and face the complexity of making judgments based on information that, being incomplete or limited, includes reflections on the social and ethical responsibilities linked to the application of their knowledge and judgments. |
| B4   | CB9 - That the students know how to communicate their conclusions -and the knowledge and ultimate reasons that sustain them- to specialized and non-specialized audiences in a clear and unambiguous way.                                                                           |
| B5   | CB10 - That students have the learning skills that allow them to continue studying in a way that will be largely self-directed or autonomous.                                                                                                                                       |
| B6   | G1 - Have adequate knowledge of the scientific and technological aspects in Industrial Engineering.                                                                                                                                                                                 |
| B13  | G8 - Apply the knowledge acquired and solve problems in new or unfamiliar environments within broader and multidisciplinary contexts.                                                                                                                                               |
| B14  | G9 - Be able to integrate knowledge and face the complexity of making judgments based on information that, being incomplete or limited, includes reflections on social and ethical responsibilities linked to the application of their knowledge and judgments.                     |



|     |                                                                                                                                                                                                                                           |
|-----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| B15 | G10 - Knowing how to communicate the conclusions -and the knowledge and ultimate reasons that sustain them- to specialized and non-specialized publics in a clear and unambiguous way.                                                    |
| B16 | G11 - Possess the learning skills that allow to continue studying in a self-directed or autonomous way.                                                                                                                                   |
| C1  | ABET (a) - An ability to apply knowledge of mathematics, science, and engineering.                                                                                                                                                        |
| C2  | ABET (b) - An ability to design and conduct experiments, as well as to analyze and interpret data.                                                                                                                                        |
| C3  | ABET (c) - An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability. |
| C6  | ABET (f) - An understanding of professional and ethical responsibility.                                                                                                                                                                   |
| C7  | ABET (g) - An ability to communicate effectively.                                                                                                                                                                                         |
| C8  | ABET (h) - The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.                                                                                    |
| C9  | ABET (i) - A recognition of the need for, and an ability to engage in life-long learning.                                                                                                                                                 |
| C11 | ABET (k) - An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.                                                                                                                     |

| Learning outcomes                                                                                                 |  |                             |      |
|-------------------------------------------------------------------------------------------------------------------|--|-----------------------------|------|
| Learning outcomes                                                                                                 |  | Study programme competences |      |
| Comprender os mecanismos de corrosión.                                                                            |  | BJ1                         | CJ1  |
|                                                                                                                   |  | BJ4                         | CJ2  |
|                                                                                                                   |  | BJ5                         | CJ3  |
|                                                                                                                   |  | BJ6                         | CJ6  |
|                                                                                                                   |  | BJ13                        | CJ7  |
|                                                                                                                   |  | BJ14                        | CJ8  |
|                                                                                                                   |  | BJ15                        | CJ9  |
|                                                                                                                   |  | BJ16                        | CJ11 |
| Predicir o comportamento superficial dos materiais metálicos segundo as condicións de servizo aos que se someten. |  | BJ1                         | CJ1  |
|                                                                                                                   |  | BJ2                         | CJ2  |
|                                                                                                                   |  | BJ3                         | CJ3  |
|                                                                                                                   |  | BJ4                         | CJ6  |
|                                                                                                                   |  | BJ5                         | CJ7  |
|                                                                                                                   |  | BJ6                         | CJ8  |
|                                                                                                                   |  | BJ13                        | CJ9  |
|                                                                                                                   |  | BJ14                        | CJ11 |
| Analizar as causas do fallo superficial de materiais metálicos en servizo.                                        |  | BJ15                        |      |
|                                                                                                                   |  | BJ1                         | CJ1  |
|                                                                                                                   |  | BJ2                         | CJ2  |
|                                                                                                                   |  | BJ3                         | CJ3  |
|                                                                                                                   |  | BJ4                         | CJ6  |
|                                                                                                                   |  | BJ6                         | CJ7  |
|                                                                                                                   |  | BJ13                        | CJ8  |
|                                                                                                                   |  | BJ14                        | CJ9  |
|                                                                                                                   |  | BJ15                        | CJ11 |
|                                                                                                                   |  | BJ16                        |      |



|                                                                                                     |      |      |
|-----------------------------------------------------------------------------------------------------|------|------|
| Coñecer as técnicas de protección e tomar as medidas eficaces para evitar a deterioración do metal. | BJ1  | CJ1  |
|                                                                                                     | BJ2  | CJ2  |
|                                                                                                     | BJ3  | CJ3  |
|                                                                                                     | BJ4  | CJ6  |
|                                                                                                     | BJ5  | CJ7  |
|                                                                                                     | BJ6  | CJ8  |
|                                                                                                     | BJ13 | CJ9  |
|                                                                                                     | BJ14 | CJ11 |
|                                                                                                     | BJ15 |      |
|                                                                                                     | BJ16 |      |

| Contents                                                              |                                                                                                                                                                                                                                                                                                              |
|-----------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Topic                                                                 | Sub-topic                                                                                                                                                                                                                                                                                                    |
| 1. Introducción á corrosión                                           | Importancia económica da corrosión. Diferenzas entre a corrosión electroquímica e a corrosión a altas temperaturas.                                                                                                                                                                                          |
| 2. Fundamentos termodinámicos e cinéticos da corrosión electroquímica | Termodinámica da corrosión electroquímica. Potenciais de eléctrodo. Ecuación de Nernst. Diagramas de Pourbaix. Cinética da corrosión electroquímica. Lei de Faraday. Polarización. Clasificación dos fenómenos de polarización. Pasivación.                                                                  |
| 3. Tipos de corrosión electroquímica                                  | Corrosión uniforme. Corrosión galvánica. Correntes erráticas. Aireación diferencial. Corrosión por picaduras. Corrosión intergranular. Corrosión microbiológica. Corrosión selectiva. Corrosión baixo tensión. Fatiga con corrosión. Corrosión-erosión. Corrosión con fricción. Fragilización por hidróxeno. |
| 4. Corrosión a alta temperaturas                                      | Termodinámica da corrosión a altas temperaturas. Mecanismos de formación dos óxidos a altas temperaturas. Diagramas de Ellingham. Cinética da corrosión a altas temperaturas. Sulfuración. Corrosión quente.                                                                                                 |
| 5. Protección fronte á corrosión                                      | Protección catódica por ánodos de sacrificio. Protección catódica por correntes impresas. Protección anódica. Recubrimentos orgánicos: pinturas. Recubrimentos inorgánicos. Inhibidores de corrosión.                                                                                                        |
| 6. Introducción á triboloxía                                          | Historia da Triboloxía. Importancia Industrial. Fricción, lubricación e desgaste.                                                                                                                                                                                                                            |
| 7. Desgaste                                                           | Conceptos xerais sobre o desgaste. Tipos de desgaste. Ensaos de desgaste                                                                                                                                                                                                                                     |
| 8. Protección contra o desgaste                                       | Introdución á lubricación. Tipos e propiedades dos lubricantes                                                                                                                                                                                                                                               |

| Planning                       |                                                                     |                      |                               |             |
|--------------------------------|---------------------------------------------------------------------|----------------------|-------------------------------|-------------|
| Methodologies / tests          | Competencies                                                        | Ordinary class hours | Student?s personal work hours | Total hours |
| Laboratory practice            | B1 B2 B3 B4 B5 B13<br>B15 B14 B16 B6 C1<br>C2 C3 C6 C7 C8 C9<br>C11 | 4                    | 0                             | 4           |
| Supervised projects            | B1 B2 B3 B4 B5 B13<br>B15 B14 B16 B6 C1<br>C3 C6 C7 C8 C9 C11       | 2                    | 12                            | 14          |
| Objective test                 | B1 B2 B3 B4 B5 B13<br>B15 B14 B16 B6 C1<br>C7 C9                    | 2                    | 46                            | 48          |
| Guest lecture / keynote speech | B1 B2 B4 B5 B13 B15<br>B14 B16 B6 C1 C2<br>C3 C6 C7 C8 C9 C11       | 22                   | 22                            | 44          |
| Personalized attention         |                                                                     | 2.5                  | 0                             | 2.5         |

(\*)The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.



## Methodologies

| Methodologies                  | Description                                                                                                                                                                                                     |
|--------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Laboratory practice            | Realizaranse prácticas nas que se mostrará os alumnos distintos aspectos da corrosión e triboloxía de materiais metálicos.                                                                                      |
| Supervised projects            | Realizarase un traballo en grupo cuxo título será proposto polos propios alumnos con obxecto de incentivar a súa creatividade e iniciativa.                                                                     |
| Objective test                 | Realizarase unha serie de pequenos controis en horas de clases sobre a temática das últimas clases.                                                                                                             |
| Guest lecture / keynote speech | Realizarase unha exposición oral complementada co uso de medios audiovisuais e a introdución dalgunhas preguntas dirixidas aos estudantes, coa finalidade de transmitir coñecementos e facilitar a aprendizaxe. |

## Personalized attention

| Methodologies                                                                                  | Description                                                                                                                                                                                                                              |
|------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Guest lecture / keynote speech<br>Laboratory practice<br>Supervised projects<br>Objective test | A atención personalizada realizarase nas titorías ben por iniciativa do alumnado para aclarar ou resolver as súas dúbidas ou dificultades ou ben por iniciativa do profesor convocando persoalmente o alumnado cando a ocasión o requira |

## Assessment

| Methodologies       | Competencies                                                  | Description                                                                                                                                 | Qualification |
|---------------------|---------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| Supervised projects | B1 B2 B3 B4 B5 B13<br>B15 B14 B16 B6 C1<br>C3 C6 C7 C8 C9 C11 | Realizarase un traballo en grupo cuxo título será proposto polos propios alumnos con obxecto de incentivar a súa creatividade e iniciativa. | 35            |
| Objective test      | B1 B2 B3 B4 B5 B13<br>B15 B14 B16 B6 C1<br>C7 C9              | Realizarase unha serie de pequenos controis en horas de clases sobre a temática das últimas clases.                                         | 65            |

## Assessment comments

O alumnado con dispensa académica estará exento de asistir ás sesións maxistras e prácticas de laboratorio. A súa cualificación realizarase da seguinte maneira:

Traballo tutelado. Poderá presentarse en forma individual no canto de en grupo. O prazo de presentación será o mesmo que para o resto do alumnado. Proba obxectiva. Deberá realizar o exame nas datas aprobadas pola Xunta de Escola da EPS de Ferrol, as cales aparecen na páxina web da Escola.

## Sources of information

|              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Basic</b> | <ul style="list-style-type: none"> <li>- Gómez de León, F.C. (2004). Manual básico de corrosión para ingenieros. Murcia: Universidad de Murcia</li> <li>- Davis J.R. (2001). Surface engineering for corrosion and wear resistance. Materials Park (Ohio): ASM International</li> <li>- Otero Huerta, E. (1997). Corrosión y degradación de materiales. Madrid: Síntesis</li> <li>- Trethewey, K.R. (1995). Corrosion for science and engineering. Essex: Longman</li> <li>- Andrade M.C. (1991). Corrosión y protección metálicas . Madrid: CSIC</li> <li>- Fontana M.G. (1986). Corrosion engineering. New York: MacGraw-Hill</li> <li>- González Fernández J.A. (1984). Teoría y práctica de la lucha contra la corrosión. Madrid: CSIC</li> <li>- Sarkar A.D. (1999). Desgaste de metales. México: Limusa</li> <li>- Martínez Pérez (2011). Tribología integral. México: Limusa</li> <li>- Valverde Martínez A. (1985). Fundamentos y técnicas de la lubricación. Madrid: editorial Alcion</li> </ul> |
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|                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Complementary</b> | <ul style="list-style-type: none"><li>- Lai G.Y. (1990). High-temperature corrosion of engineering alloys. Materials Park (Ohio): ASM International</li><li>- Chawla S.L. (1993). Materials selection for corrosion contro. Materials Park (Ohio): ASM International</li><li>- Shreir L.L. (1994). Corrosion Vol.1. Oxford: Butterworth-Heineman</li><li>- Shreir L.L. (1994). Corrosion Vol.2. Oxford: Butterworth-Heineman</li><li>- Piron D.L. (1991). The electrochemistry of corrosion. Houston: Nace</li><li>- Molera Solé P. (1989). Metales resistentes a la corrosión. Barcelona: Marcombo</li><li>- Ramsey Gohar (2012). Fundamentals of tribology. Imperial college press</li><li>- Wen Shizhu (2012). Principles of tribology. Tsinghua university press</li><li>- Muños Machado, J. (2009). Apuntes de tribología. Madrid: PMaraven</li></ul> |
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## Recommendations

Subjects that it is recommended to have taken before

Subjects that are recommended to be taken simultaneously

Subjects that continue the syllabus

## Other comments

A entrega dos traballos documentais que se realicen nesta materia realizarase a través de Moodle ou correo electrónico en formato dixital sen necesidade de imprimilos.

(\*)The teaching guide is the document in which the URV publishes the information about all its courses. It is a public document and cannot be modified. Only in exceptional cases can it be revised by the competent agent or duly revised so that it is in line with current legislation.