



| Guía Docente          |  |                    |   |          |
|-----------------------|--|--------------------|---|----------|
| Datos Identificativos |  |                    |   | 2022/23  |
| Asignatura (*)        | Vehículos Mariños Autónomos  | Código             | 730542017                                       |          |
| Titulación            |  |                    |   |          |
| Descriptorios         |  |                    |   |          |
| Ciclo                 | Período  | Curso              | Tipo  | Créditos |
| Mestrado Oficial      | 2º cuatrimestre  | Primeiro           | Optativa  | 6        |
| Idioma                | Inglés   |                    |   |          |
| Modalidade docente    | Presencial   |                    |   |          |
| Prerrequisitos        |  |                    |   |          |
| Departamento          | Ciencias da Computación e Tecnoloxías da Información Matemáticas   |                    |   |          |
| Coordinación          | Bellas Bouza, Francisco Javier   | Correo electrónico | francisco.bellas@udc.es                         |          |
| Profesorado           | Bellas Bouza, Francisco Javier<br>Orjales Saavedra, Félix  | Correo electrónico | francisco.bellas@udc.es<br>felix.orjales@udc.es |          |
| Web                   | <a href="http://www.master-seas40.unina.it">http://www.master-seas40.unina.it</a>  |                    |   |          |
| Descrición xeral      | The main objective of the course is to provide the students with an updated vision of autonomous marine vehicles, both surface and underwater systems. The topics are mainly focused on providing students with the basics of intelligent control systems in marine environments. In addition, it will also provide a technical and regulatory approach to the field of robotics within this scope. In order to obtain these goals, and apart from the theoretical basis, students will work with simulated and real marine vehicles, thus developing the skills needed to tackle the implementation of real autonomous marine robots. |                    |   |          |

| Competencias / Resultados do título |                                     |
|-------------------------------------|-------------------------------------|
| Código                              | Competencias / Resultados do título |

| Resultados da aprendizaxe  |                                     |   |                                 |
|--|-------------------------------------|---|---------------------------------|
| Resultados de aprendizaxe  | Competencias / Resultados do título |   |                                 |
| Capacity for applying mathematical and ICT methods and tools to define, design, operate and maintain advanced marine robotic systems and for understanding and developing the needed algorithms and methods. |                                     | BM1<br>BM2<br>BM3<br>BM4<br>BM5<br>BM6<br>BM7<br>BM10<br>BM12 | CM2<br>CM3<br>CM4<br>CM6<br>CM7 |
| Understanding the difference between autonomous and non-autonomous operation in robotics, and how it fits into the Artificial Intelligence field   | AM4                                 | BM3<br>BM5<br>BM7<br>BM12                                     | CM4                             |
| Acquiring the knowledge about sensors and actuators relevant in marine vehicles to provide them with autonomous capabilities   | AM4                                 | BM1<br>BM3<br>BM5<br>BM7<br>BM12                              | CM4<br>CM6<br>CM7               |



|  |     |  |                          |
|--|-----|--|--------------------------|
| Understanding the fundamentals of autonomous robotic control, and how classical techniques are very important to achieve a proper response. Being able to apply these concepts in navigation tasks | AM4 | BM1<br>BM2<br>BM3<br>BM5<br>BM7<br>BM12                | CM3<br>CM4<br>CM6<br>CM7 |
| Capacity for using a marine vehicle simulator and programming it, including all the previous knowledge about sensors, actuators and autonomous/classical control                                   | AM4 | BM2<br>BM3<br>BM5<br>BM6<br>BM7<br>BM8<br>BM10<br>BM12 | CM3<br>CM6<br>CM7        |

| Contidos  |   |
|---|---|
| Temas   | Subtemas  |
| Topic 1. Introduction to autonomous vehicles      | <ul style="list-style-type: none"> <li>- Artificial Intelligence</li> <li>- Autonomous vehicles</li> <li>- Autonomous marine vehicles</li> <li>- Regulatory issues</li> </ul>   |
| Topic 2. Sensors and actuators in marine vehicles | <ul style="list-style-type: none"> <li>- Sensors:               <ul style="list-style-type: none"> <li>-- Sound based (Sonar, DVL, range finders...)</li> <li>-- Vision and laser based (Cameras, LIDAR...)</li> <li>-- Inertial Measurement Units (IMU)</li> <li>-- GNSS and alternative positioning systems</li> </ul> </li> <li>- Actuators:               <ul style="list-style-type: none"> <li>-- Thrusters and alternative propulsion methods</li> <li>-- Arms and grippers</li> </ul> </li> </ul> |
| Topic 3. Autonomous control                       | <ul style="list-style-type: none"> <li>- Open loop control</li> <li>- Closed loop control</li> <li>- PID</li> <li>- Intelligent architectures               <ul style="list-style-type: none"> <li>-- Reactive</li> <li>-- Deliberative</li> <li>-- Hybrid</li> </ul> </li> </ul>   |
| Topic 4. Autonomous navigation                    | <ul style="list-style-type: none"> <li>- Localization</li> <li>- Mapping</li> <li>- Path planning</li> </ul>  |
| Topic 5. Programming underwater vehicles          | <ul style="list-style-type: none"> <li>- Gazebo simulation model</li> <li>- Programming framework</li> <li>- Real underwater vehicle</li> </ul>   |

| Planificación             |                           |   |                         |              |
|---------------------------|---------------------------|---|-------------------------|--------------|
| Metodoloxías / probas     | Competencias / Resultados | Horas lectivas (presenciais e virtuais) | Horas traballo autónomo | Horas totais |
| Prácticas a través de TIC | B3 B6 B8 C3 C6            | 18                                      | 18                      | 36           |
| Sesión maxistral          | B2 B4 B6 C4 C6            | 18                                      | 9                       | 27           |



|                        |  |   |    |    |
|------------------------|--|---|----|----|
| Traballos tutelados    | A4 B3 B4 B5 B6 B7<br>B8 B9 B11 B13 C2<br>C3 C7 | 0 | 55 | 55 |
| Saídas de campo        | A4 B3 B7 B9 B11 B13<br>C4 C7                   | 4 | 8  | 12 |
| Proba mixta            | A4 B4 B5 B6 B11 B13<br>C2                      | 2 | 16 | 18 |
| Atención personalizada |  | 2 | 0  | 2  |

\*Os datos que aparecen na táboa de planificación son de carácter orientativo, considerando a heteroxeneidade do alumnado

| Metodoloxías              |  |
|---------------------------|--|
| Metodoloxías              | Descrición   |
| Prácticas a través de TIC | Practical classes carried out in the ICT lab, with the objective of learning how to program an autonomous marine vehicle (real or simulated) to develop a simple mission. In these classes, the teacher will help students to properly understand the topics   |
| Sesión maxistral          | Masterclass where teachers explain the theoretical concepts of the topics, and students can ask questions.   |
| Traballos tutelados       | Autonomous work where students must solve some challenge involving programming an autonomous marine vehicle to solve a task. There can be one of incremental complexity or more than one with independent objectives. In this methodology, students will be organised in groups, so they will have to collaborate to achieve the goal. |
| Saídas de campo           | A field trip will be made to the UDC ship model basin to analyse the real conditions of the environment where the ROV operates   |
| Proba mixta               | Written or oral examination where students will show their understanding of the theoretical concepts of the subject.   |

| Atención personalizada    |   |
|---------------------------|---|
| Metodoloxías              | Descrición  |
| Prácticas a través de TIC | In the practical workshops, the teacher will supervise the students' progress and help them with all the issues that could arise.                           |
| Traballos tutelados       | In the supervised projects, students will have the option of asking their questions and doubts to the teachers while developing their project autonomously. |

| Avaliación          |  |  |               |
|---------------------|--|--|---------------|
| Metodoloxías        | Competencias / Resultados                      | Descrición   | Cualificación |
| Proba mixta         | A4 B4 B5 B6 B11 B13<br>C2                      | Students will have to show their knowledge and understanding of the theoretical concepts of the subject by means of a written or oral activity   | 30            |
| Traballos tutelados | A4 B3 B4 B5 B6 B7<br>B8 B9 B11 B13 C2<br>C3 C7 | One or more incremental projects will be proposed throughout the course focused on solving realistic problems with autonomous marine problems using real or simulated robots. These tasks will be developed autonomously by the student outside the classroom and must be defended in front of the teachers. | 60            |
| Saídas de campo     | A4 B3 B7 B9 B11 B13<br>C4 C7                   | The correct preparation, execution and understanding of the field trip will be assessed by the teachers of the subject. Students must prepare a report which will be evaluated.  | 10            |

| Observacións avaliación |
|-------------------------|
|-------------------------|



In order to pass this subject, a minimum score of 50 must be obtained by adding all the above methodologies, there being no minimum in any of them. If the student does not pass the subject in the ordinary exam, he/she will have to repeat the necessary activities of the methodology/s that were not passed in the extraordinary exam.

General EMJMD Sustainable Ship and Shipping SEAS 4.0 evaluation rules:

- Students will have only two opportunities to pass a course. If failing to do so, they may be forced to leave the degree.
- No part time or lecture attendance exemption are allowed in this degree.

## Fontes de información

|                                    |  |
|------------------------------------|--|
| <b>Bibliografía básica</b>         | <ul style="list-style-type: none"><li>- Thor I. Fossen (2011). Handbook of Marine Craft Hydrodynamics and Motion Control. John Wiley &amp; Sons</li><li>- Geoff Roberts and Robert Sutton (2006). Advances in unmanned marine vehicles. Institution of Engineering and Technology</li><li>- Robin R. Murphy (2000). Introduction to AI Robotics. A Bradford Book</li><li>- Dronekit (2015). <a href="https://dronekit-python.readthedocs.io/en/latest/">https://dronekit-python.readthedocs.io/en/latest/</a>.</li></ul> |
| <b>Bibliografía complementaria</b> | <ul style="list-style-type: none"><li>- Joseph, Lentin (2015). Learning robotics using Python : design, simulate, program, and prototype an interactive autonomous mobile robot from scratch with the help of Python, ROS, and Open-CV. Packt Publishing</li></ul>   |

## Recomendacións

### Materias que se recomenda ter cursado previamente

Marco Regulamentario para a Industria Marítima 4.0/730542001

Robótica e Robótica Submarina/730542007

### Materias que se recomenda cursar simultaneamente

Internet das Cousas Aplicado á Industria (IIoT)/730542015

Tecnoloxías Facilitadoras da Industria 4.0/730542010

### Materias que continúan o temario

## Observacións

To help in achieving a sustainable environment and to get the objective of number 5 action of the "Ferrol Green Campus Action Plan" (Healthy and environmental and socially sustainable research and teaching): The assignments to be done in this course:- Will be required in digital format.- Will be delivered using Moodle, with no need to print them. In case it is necessary to print them:- Plastics won't be used.- Two side printing will be used.- Recycled paper will be used.- Printing drafts will be avoided. A sustainable use of the resources should be done, together with the prevention of negative impacts on the environment.&nbsp;

(\*A Guía docente é o documento onde se visualiza a proposta académica da UDC. Este documento é público e non se pode modificar, salvo casos excepcionais baixo a revisión do órgano competente dacordo coa normativa vixente que establece o proceso de elaboración de guías