Teaching Guide				
Identifying Data				2022/23
Subject (*)	Autonomous Marine Vehicles		Code	730542017
Study programme	Master Universitario Erasmus Mundus en Sostibilidade e Industria 4.0 aplicada ao Sector Marítimo			
Descriptors				
Cycle	Period	Year	Type	Credits
Official Master's Degree	2nd four-month period	First	Optional	6
Language	English			
Teaching method	Face-to-face			
Prerequisites				
Department	Ciencias da Computación e Tecnoloxías da InformaciónMatemáticas			
Coordinador	Bellas Bouza, Francisco Javier	E-mail	francisco.bellas@udc.es	
Lecturers	Bellas Bouza, Francisco Javier Orjales Saavedra, Félix	E-mail	francisco.bellas@udc.es felix.orjales@udc.es	
Web	http://www.master-seas40.unina.it			
General description	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.			

Study programme competences / results	
Code	Study programme competences / results
A4	CE4 ? Demonstrate knowledge, understanding and competences in the field of design and operation of robots and marine autonomous vehicles (RAS).
B2	CB6 - Acquire and understand knowledge that provides a basis or opportunity to be original in the development and / or application of ideas, usually in a research context.
B3	CB7 - That students know how to apply the acquired knowledge and their ability to solve problems in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their area of study.
B4	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.
B5	CB9 ? That students are able to communicate their conclusions -and the knowledge and ultimate reasons that sustain them- to specialized and non-specialized publics in a clear and unambiguous way.
B6	CB10 - That students have the learning skills that allow them to continue studying in a way that will be largely self-directed or autonomous.
B7	CG1 ? To display the adequate intercultural competence to successfully navigating within multicultural learning environments and to implement basic management principles suitable for a multicultural working environment.
B8	CG2 ? To express an attitude of intellectual inquisitiveness and open-mindedness.
B9	CG3 ? To have the capability to use knowledge, skills, ideas, theory, and modern engineering concepts to create new or significantly improved real engineering applications.
B11	CG5 ? To have the capability to identify, formulate and solve engineering problems within realistic constraints.
B13	CG7 ? To have the capability to critically analyse, synthesise, interpret and summarise complex scientific processes.
C2	CT2 - Mastering oral and written expression in a foreign language.
C3	CT3 - Using ICT in working contexts and lifelong learning.
C4	CT4 - Acting as a respectful citizen according to democratic cultures and human rights and with a gender perspective.
C6	CT6 - Acquiring skills for healthy lifestyles, and healthy habits and routines.
C7	CT7 -Developing the ability to work in interdisciplinary or transdisciplinary teams in order to offer proposals that can contribute to a sustainable environmental, economic, political and social development.

Learning outcomes

Learning outcomes	Study programme competences / results		
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.		BC1 BC2 BC3 BC4 BC5 BC6 BC7 BC10 BC12	CC2 CC3 CC4 CC6 CC7
Understanding the difference between autonomous and non-autonomous operation in robotics, and how it fits into the Artificial Intelligence field	AC4	BC3 BC5 BC7 BC12	CC4
Acquiring the knowledge about sensors and actuators relevant in marine vehicles to provide them with autonomous capabilities	AC4	BC1 BC3 BC5 BC7 BC12	CC4 CC6 CC7
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	AC4	BC1 BC2 BC3 BC5 BC7 BC12	CC3 CC4 CC6 CC7
Capacity for using a marine vehicle simulator and programming it, including all the previous knowledge about sensors, actuators and autonomous/classical control	AC4	BC2 BC3 BC5 BC6 BC7 BC8 BC10 BC12	CC3 CC6 CC7

Contents	
Topic	Sub-topic
Topic 1. Introduction to autonomous vehicles	- Artificial Intelligence - Autonomous vehicles - Autonomous underwater vehicles - Regulatory issues
Topic 2. Sensors and actuators in marine vehicles	- Sensors: -- Sound based (Sonar, DVL, range finders...) -- Vision and laser based (Cameras, LIDAR...) -- Inertial Measurement Units (IMU) -- GNSS and alternative positioning systems - Actuators: -- Thrusters and alternative propulsion methods -- Arms and grippers

Topic 3. Autonomous control	- Open loop control - Closed loop control - PID - Intelligent architectures -- Reactive -- Deliberative -- Hybrid
Topic 4. Autonomous navigation	- Localization - Mapping - Path planning
Topic 5. Programming underwater vehicles	- Gazebo simulation model - Programming framework - Real underwater vehicle

Planning				
Methodologies / tests	Competencies / Results	Teaching hours (in-person & virtual)	Student?s personal work hours	Total hours
ICT practicals	B3 B6 B8 C3 C6	18	18	36
Guest lecture / keynote speech	B2 B4 B6 C4 C6	18	9	27
Supervised projects	A4 B3 B4 B5 B6 B7 B8 B9 B11 B13 C2 C3 C7	0	55	55
Field trip	A4 B3 B7 B9 B11 B13 C4 C7	4	8	12
Mixed objective/subjective test	A4 B4 B5 B6 B11 B13 C2	2	16	18
Personalized attention		2	0	2
(*)The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.				

Methodologies	
Methodologies	Description
ICT practicals	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
Guest lecture / keynote speech	Masterclass where teachers explain the theoretical concepts of the topics, and students can ask questions.
Supervised projects	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.
Field trip	A field trip will be made to the UDC ship model basin to analyse the real conditions of the environment where the ROV operates
Mixed objective/subjective test	Written or oral examination where students will show their understanding of the theoretical concepts of the subject.

Personalized attention	
Methodologies	Description

ICT practicals Supervised projects	In the practical workshops, the teacher will supervise the students' progress and help them with all the issues that could arise. In the supervised projects, students will have the option of asking their questions and doubts to the teachers while developing their project autonomously.

Assessment			
Methodologies	Competencies / Results	Description	Qualification
Mixed objective/subjective test	A4 B4 B5 B6 B11 B13 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
Supervised projects	A4 B3 B4 B5 B6 B7 B8 B9 B11 B13 C2 C3 C7	One or more 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
Field trip	A4 B3 B7 B9 B11 B13 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

Assessment comments
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 oportunities 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.

Sources of information	
Basic	- Thor I. Fossen (2011). Handbook of Marine Craft Hydrodynamics and Motion Control. John Wiley & Sons - Geoff Roberts and Robert Sutton (2006). Advances in unmanned marine vehicles. Institution of Engineering and Technology - Robin R. Murphy (2000). Introduction to AI Robotics. A Bradford Book - Dronekit (2015). https://dronekit-python.readthedocs.io/en/latest/.
Complementary	- 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

Recommendations
Subjects that it is recommended to have taken before
Regulatory Framework for Maritime Industry 4.0/730542001 Robotics & Underwater Robotics/730542007
Subjects that are recommended to be taken simultaneously
Industrial Internet of Things (IIoT)/730542015 Industry 4.0 Enabling Technologies/730542010
Subjects that continue the syllabus
Other comments

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 environmentaly 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.