



# UNIVERSIDAD DE CASTILLA - LA MANCHA

## GUÍA DOCENTE

### 1. General information

**Course:** AUTONOMOUS ROBOTICS

**Type:** ELECTIVE

**Degree:** 406 - UNDERGRADUATE DEGREE IN COMPUTER SCIENCE AND ENGINEERING (AB)

**Center:** 604 - SCHOOL OF COMPUTER SCIENCE AND ENGINEERING (AB)

**Year:** 4

**Main language:** English

**Use of additional languages:**

**Web site:** <https://campusvirtual.uclm.es>

**Code:** 42361

**ECTS credits:** 6

**Academic year:** 2023-24

**Group(s):** 17

**Duration:** C2

**Second language:**

**English Friendly:** Y

**Bilingual:** N

**Lecturer:** JESUS MARTINEZ GOMEZ - Group(s): 17

Building/Office	Department	Phone number	Email	Office hours
Agrupación Politécnica/ Desp. 1.E.4	SISTEMAS INFORMÁTICOS	967599365	jesus.martinez@uclm.es	<a href="https://www.esiab.uclm.es/pers.php?codpers=723&amp;curso=2023-24">https://www.esiab.uclm.es/pers.php?codpers=723&amp;curso=2023-24</a>

### 2. Pre-Requisites

Students should have a solid background in computer programming and algorithms, and basic knowledge in calculus, linear algebra, and statistics. Such background and knowledge should have been obtained through the completion of the corresponding first-year courses.

Assignments will require the use of Python programming language, and the completion of the Intelligent Systems course is highly recommended.

Any experience with any modern procedural language (e.g. C++) should be sufficient in any case.

Assignments and/or seminar may involve the use of Linux as operating system, so the completion of the Operating Systems course is highly recommended

### 3. Justification in the curriculum, relation to other subjects and to the profession

This course will introduce students to the fundamental constraints, technologies, and algorithms of autonomous robotics. The focus will be on computational aspects of autonomous wheeled mobile robots. The most important themes will be mobility, perception, localization, and navigation. Assignments will require the implementation of behaviours suitable for being deployed in Mobile wheeled robots like the AWS Deep Racer car or the Pepper SoftBank Robotics Robot.

### 4. Degree competences achieved in this course

#### Course competences

Code	Description
CM02	Ability to know the theoretical fundamentals of programming languages, and their associated techniques for lexical, syntactic, and semantic processes, along with their application in the creation, design, and language processing.
CM04	Ability to know the fundamentals, paradigms, and techniques of intelligent systems, and analyse, design, and build systems, services, and digital, applications which could use such techniques in any application context.
CM07	Ability to know and develop computational learning techniques, and design and implement applications and systems which could use them, including the ones for the automatic extraction of information and knowledge from great batches of information.
INS04	Problem solving skills by the application of engineering techniques.
PER01	Team work abilities.
PER02	Ability to work in multidisciplinary teams.
PER03	Ability to work in an international context.
SIS03	Autonomous learning.
SIS08	Initiative and entrepreneurial abilities.
UCLM01	Command of a second language at a B1 level within the Common European Framework of Reference for Languages

### 5. Objectives or Learning Outcomes

#### Course learning outcomes

Description

Design and programming of basic and advanced behaviors that allow a robot to function autonomously in a specific environment.

Improvement of communication skills of the student in English language

### 6. Units / Contents

#### Unit 1: Introduction

**Unit 1.1** Mobile Robots

**Unit 1.2** Mobile Robot Architectures

**Unit 1.3** Robot Behaviours

#### Unit 2: Mobility

**Unit 2.1** Locomotion

#### Unit 3: Perception

**Unit 3.1** Robot Sensing

**Unit 3.2** Robot Vision

**Unit 3.3** Advanced Perception

**Unit 4: Localization**

**Unit 4.1** Introduction to localization

**Unit 4.2** Markov Localization

**Unit 4.3** Odometry motion model and Grid Localization

**Unit 4.4** Monte Carlo Localization

**Unit 4.5** Kalman filter localization methods

**Unit 5: Advanced Topics**

**Unit 5.1** Simultaneous Localization and Mapping (SLAM)

**Unit 5.2** Planning

**Unit 5.3** Probabilistic Planning and Human Robot Interaction (HRI)

7. Activities, Units/Modules and Methodology							
Training Activity	Methodology	Related Competences (only degrees before RD 822/2021)	ECTS	Hours	As	Com	Description
Class Attendance (theory) [ON-SITE]	Lectures	CM04 INS04 SIS03	0.78	19.5	Y	N	Theory
Computer room practice [ON-SITE]	Practical or hands-on activities	CM02 CM04 CM07 INS04 PER01	0.9	22.5	Y	N	Practices based on theoretical topics
Workshops or seminars [ON-SITE]	Workshops and Seminars	CM07 INS04 PER02 PER03 SIS08	0.36	9	Y	N	Practical cases and discussions
Project or Topic Presentations [ON-SITE]	Group Work	PER01 PER02 SIS08 UCLM01	0.18	4.5	Y	N	Presentation and discussion of team work
Individual tutoring sessions [ON-SITE]	Lectures	CM02 CM04 CM07	0.18	4.5	N	-	Tutoring
Writing of reports or projects [OFF-SITE]	Group Work	CM02 CM04 CM07 INS04 PER01 PER02	1.8	45	Y	N	Team work development and writing
Study and Exam Preparation [OFF-SITE]	Self-study	CM02 CM04 CM07 INS04 SIS03	1.8	45	Y	N	Deliveries
<b>Total:</b>			<b>6</b>	<b>150</b>			
<b>Total credits of in-class work: 2.4</b>			<b>Total class time hours: 60</b>				
<b>Total credits of out of class work: 3.6</b>			<b>Total hours of out of class work: 90</b>				

As: Assessable training activity

Com: Training activity of compulsory overcoming (It will be essential to overcome both continuous and non-continuous assessment).

8. Evaluation criteria and Grading System			
Evaluation System	Continuous assessment	Non-continuous evaluation*	Description
Progress Tests	25.00%	40.00%	[PRES][ESC] - Continuous assessment: The evaluation of this activity is IN GROUPS Oral presentation in class and questions about a work already documented and submitted - Non-continuous evaluation The evaluation of this activity is INDIVIDUAL Theoretical exam
Theoretical papers assessment	15.00%	30.00%	[INF] - Continuous assessment / Non-continuous evaluation The evaluation of this activity is IN GROUPS Evaluation of a memory about a work previously submitted
Laboratory sessions	40.00%	30.00%	[LAB] - Continuous assessment / Non-continuous evaluation The evaluation of this activity is INDIVIDUAL Evaluation of the submissions resulting the from laboratory practices
Assessment of active participation	20.00%	0.00%	[PRES] - Continuous assessment: The evaluation of this activity is INDIVIDUAL Active participation during activities of relevant importance like seminars
<b>Total:</b>	<b>100.00%</b>	<b>100.00%</b>	

According to art. 4 of the UCLM Student Evaluation Regulations, it must be provided to students who cannot regularly attend face-to-face training activities the passing of the subject, having the right (art. 12.2) to be globally graded, in 2 annual calls per subject, an ordinary and an extraordinary one (evaluating 100% of the competences).

**Evaluation criteria for the final exam:**

**Continuous assessment:**

Students will work individually in the laboratory sessions, with some submissions that will determine 40% of the final mark.

Students will work in groups on the documentation and presentation of a work related to some of the robotics topics presented during the theoretical lessons, and previously proposed by the teachers. The quality of the memory will determine 15% of the final mark. The oral presentation, defence, and

overall quality will determine 25% of the final mark.

- 25% of the final mark will be set based on the oral presentation and defence of a team work
- 15% of the final mark will be set based on the memory of a team work
- 40% of the final mark will be set based on the individual laboratory assignments
- 20% of the final mark will be set based on the active participation of relevant activities like seminars, case studies or problem-solving.

There are no restrictions about requesting a minimal mark in a given part to pass the course.

By default, the student will be evaluated by continuous evaluation. If you wish to change to non-continuous evaluation, you must indicate it through the following link <https://www.esiib.uclm.es/alumnos/evaluacion.php> before the end of the term and as long as you have not submitted 50% or more of the subject by continuous evaluation.

#### Non-continuous evaluation:

Students will work individually in the laboratory sessions, with some submissions that will determine 30% of the final mark.

Students will work in groups on the documentation of a work related to some of the robotics topics presented during the theoretical lessons, and previously proposed by the teachers. The quality of the memory will determine 30% of the final mark.

There will be a progress exam that will determine 40% of the final mark

- 40% of the final mark will be set based on an individual theoretical exam.
- 30% of the final mark will be set based on the memory of a team work
- 30% of the final mark will be set based on the individual laboratory assignments

There are no restrictions about requesting a minimal mark in a given part to pass the course.

#### Specifications for the resit/retake exam:

The same criteria as for the non-continuous evaluation will be applied. Students can maintain the grades obtained during the continuous assessment for the work in teams (30% of the final grade) and laboratory submissions (30% of the final grade). This deliverables, along with the theoretical exam, will allow recovering 100% of the final grade.

#### Specifications for the second resit / retake exam:

A written exam, covering all the theoretical and practical aspects of the subject, will determine 100% of the final mark.

9. Assignments, course calendar and important dates	
Not related to the syllabus/contents	
Hours	hours
Workshops or seminars [PRESENCIAL][Workshops and Seminars]	9
Project or Topic Presentations [PRESENCIAL][Group Work]	4.5
Individual tutoring sessions [PRESENCIAL][Lectures]	4.5
Writing of reports or projects [AUTÓNOMA][Group Work]	45
Study and Exam Preparation [AUTÓNOMA][Self-study]	45
<b>General comments about the planning:</b> This course schedule is APPROXIMATE. It could vary throughout the academic course due to teaching needs, bank holidays, etc. A weekly schedule will be properly detailed and updated on the online platform (Virtual Campus). Note that all the lectures, practice sessions, exams and related activities performed in the bilingual groups will be entirely taught and assessed in English. Classes will be scheduled in 3 sessions of one hour and a half per week. The assessment activities could be performed in the afternoon, in case of necessity.	
Unit 1 (de 5): Introduction	
Activities	Hours
Class Attendance (theory) [PRESENCIAL][Lectures]	7.5
Computer room practice [PRESENCIAL][Practical or hands-on activities]	4.5
Unit 2 (de 5): Mobility	
Activities	Hours
Class Attendance (theory) [PRESENCIAL][Lectures]	1.5
Computer room practice [PRESENCIAL][Practical or hands-on activities]	4.5
Unit 3 (de 5): Perception	
Activities	Hours
Class Attendance (theory) [PRESENCIAL][Lectures]	4.5
Computer room practice [PRESENCIAL][Practical or hands-on activities]	4.5
Unit 4 (de 5): Localization	
Activities	Hours
Class Attendance (theory) [PRESENCIAL][Lectures]	3
Computer room practice [PRESENCIAL][Practical or hands-on activities]	4.5
Unit 5 (de 5): Advanced Topics	
Activities	Hours
Class Attendance (theory) [PRESENCIAL][Lectures]	3
Computer room practice [PRESENCIAL][Practical or hands-on activities]	4.5
Global activity	
Activities	hours
Class Attendance (theory) [PRESENCIAL][Lectures]	19.5
Computer room practice [PRESENCIAL][Practical or hands-on activities]	22.5
Project or Topic Presentations [PRESENCIAL][Group Work]	4.5
Individual tutoring sessions [PRESENCIAL][Lectures]	4.5
Workshops or seminars [PRESENCIAL][Workshops and Seminars]	9
Writing of reports or projects [AUTÓNOMA][Group Work]	45
Study and Exam Preparation [AUTÓNOMA][Self-study]	45
<b>Total horas: 150</b>	

## 10. Bibliography and Sources

Author(s)	Title/Link	Publishing house	Citv	ISBN	Year	Description
Nikolaus Correll	Introduction to Autonomous Robots  <a href="https://github.com/correll/Introduction-to-Autonomous-Robots">https://github.com/correll/Introduction-to-Autonomous-Robots</a>	Magellan Scientific		978-0692700877	2020	This book introduces concepts in mobile, autonomous robotics to 3rd-4th year students in Computer Science or a related discipline. The book covers principles of robot motion, forward and inverse kinematics of robotic arms and simple wheeled platforms, perception, error propagation, localization and simultaneous localization and mapping. The cover picture shows a wind-up toy that is smart enough to not fall off a table just using intelligent mechanism design and illustrate the importance of the mechanism in designing intelligent, autonomous systems. This book is open source, open to contributions, and released under a creative common license.
Bekey, George A.	Autonomous robots : from biological inspiration to implement	The Mit Press		0-262-02578-7	2005	An introduction to the science and practice of autonomous robots that reviews over 300 current systems and examines the underlying technology. Autonomous Robots: Modeling , Path Planning, and Control is suitable for mechanical and electrical engineers who want to familiarize themselves with methods of modeling/analysis/control that have been proven efficient through research. This book presents the theoretical tools for analyzing the dynamics of and controlling Autonomous Robots in a form comprehensible for students and engineers. Niku offers comprehensive, yet concise coverage of robotics that will appeal to engineers. Robotic applications are drawn from a wide variety of fields. Emphasis is placed on design along with analysis and modeling. Kinematics and dynamics are covered extensively in an accessible style. Vision systems are discussed in detail, which is a cutting-edge area in robotics. Engineers will also find a running design project that reinforces the concepts by having them apply what they've learned. Probabilistic robotics is a new and growing area in robotics, concerned with perception and control in the face of uncertainty. Building on the field of
Fahimi, Farbod	Autonomous robots : modeling, path planning, and control	Springer		978-0-387-09537-0	2009	
Niku, Saeed B. (Saeed Benjamin)	Introduction to robotics : analysis, control, applications	Wiley		978-0-470-60446-5	2010	

Thrun, Sebastian	Probabilistic robotics	The MIT Press	0-262-20162-3	2005	<p>mathematical statistics, probabilistic robotics endows robots with a new level of robustness in real-world situations. This book introduces the reader to a wealth of techniques and algorithms in the field. All algorithms are based on a single overarching mathematical foundation. Each chapter provides example implementations in pseudo code, detailed mathematical derivations, discussions from a practitioner's perspective, and extensive lists of exercises and class projects.</p> <p>It has long been the goal of engineers to develop tools that enhance our ability to do work, increase our quality of life, or perform tasks that are either beyond our ability, too hazardous, or too tedious to be left to human efforts. Autonomous mobile robots are the culmination of decades of research and development, and their potential is seemingly unlimited.</p>
Frank L. Lewis, Shuzhi Sam Ge	Autonomous Mobile Robots: Sensing, Control, Decision Making and Applications	CRC Press	978-0367390891	2019	