Freie Universität Bozen
Libera Università di Bolzano
Università Liedia de Bulsan

# Syllabus
# Course description

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| **Course title** | Mobile Robotics |
| **Course code** | 47568 |
| **Scientific sector** | ING-INF/04 |
| **Degree** | Master in Industrial Mechanical Engineering |
| **Semester** | II |
| **Year** | I |
| **Academic Year** | 2022-2023 |
| **Credits** | 5 |
| **Modular** | No |

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| **Total lecturing hours** | 28 |
| **Total exercise hours** | 18 |
| **Attendance** | Attendance at lectures and exercise sessions is strongly recommended. |
| **Prerequisites** | none |
| **Course page** | Course Offering / Free University of Bozen-Bolzano (unibz.it) |

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| **Specific educational objectives** | A mobile robot is an unmanned system operating in unstructured and dynamic environments, with or without human supervision. Applications of mobile robots include environmental monitoring; manufacturing; logistics; search & rescue; construction; forestry management, agricultural monitoring and production; mining; marine measurement and monitoring; and aerospace operations. This course covers the fundamental principles of mobile robotics at an introductory level. The topics covered include the definition and characterisation of mobile robots; sensors; actuators; measurement models; state estimation; mapping; localization; planning; and control. Interactive laboratory exercises will provide hands-on experience by teaching the Robot Operating System (ROS) and how to use it to program and control a mobile robot in simulation and real life. The course is self-contained, however basic knowledge on linear algebra, probability theory and programming are recommended. |

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| **Lecturer** | Dr. Marco Camurri Facoltà di Scienze e Tecnologie, Room 601 piazza Università 3 (palazzo Provincia, 6th floor)<br>Tel.: +39 0471 017944<br>E-mail: marco.camurri@unibz.it<br>Web: ps://www.unibz.it/it/faculties/sciencetechnology/academic-ff/person/47498-marco-camurri |

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| **Scientific sector of the lecturer** | ING-INF/04 - Automatica |
| **Teaching language** | English |
| **Office hours** | As listed on Cockpit or by appointment |
| **Teaching assistant (if any)** | NN |
| **Office hours** | As listed on Cockpit or by appointment |
| **List of topics covered** | The course covers the following topics:<br>1. Introduction and Preliminaries<br>a. Definition and architecture of mobile robots<br>b. Linear algebra and probability primer<br>2. Anatomy of Mobile robots: Sensors & Actuators<br>a. Inertial Measurement Units (IMUs), Encoders, torque sensors<br>b. Cameras, Lidars, Global Navigation Satellite Systems (GNSS)<br>c. Electric and Hydraulic actuators<br>3. Principles of Wheeled and Legged Locomotion<br>4. State Estimation and Odometry<br>5. Localization and Mapping<br>6. Path Planning<br>7. Control |
| **Teaching format** | Classroom lectures and laboratory exercises |

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| **Learning outcomes (ILOs)** | <u>Knowledge and understanding</u><br><br>1. Grasping the design requirements of mobile systems, their application, the physics of their components and their architecture from a mechanical, electronical and informatics perspective<br>2. Defining sensing and controller requirements for unmanned vehicles that operate in different conditions.<br>3. Understanding factors that affect system performance and stability.<br>4. Use and application of algorithms to estimate the state, plan and execute actions.<br><br><u>Applying knowledge and understanding</u><br><br>5. Analysing, developing and presenting navigation algorithms through laboratory exercises, which complement the lectures.<br><br><u>Making judgements</u><br><br>6. On the choice of algorithmic tools to use in the lab exercises. This may require integrating knowledge, handle complexity, and formulate judgements with incomplete data.<br><br><u>Communication skills</u> |

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| | 7. Laboratory reports will require you justify your solutions/conclusions concisely (in clear and simple language).<br><br>Learning Skills<br><br>8. Students will be required to develop a proficiency in ROS, Python or C++ with in-class examples. Students will have to develop the ability to autonomously find the knowledge and tools required to achieve their objectives. |

**Assessment**

**Formative assessment**

| Form | Length /duration | ILOs assessed |
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| Exercises | 18 hours total | 1-8 |

**Summative assessment**

| Form | % | Length /duration | ILOs assessed |
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| Exercises | 60 | | 1-8 |
| Final Exam | 40 | 4 hours | 1-6 |

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| **Assessment language** | English |
| **Evaluation criteria and criteria for awarding marks** | Laboratory Exercises: Completeness and correctness of answers; level of understanding<br><br>Written Final Exam: Completeness and correctness of answers.<br><br>Students are required to receive an overall grade of greater than 60/100 points to pass the course. |
| **Required readings** | Lecture slides and other material will be available on the UniBZ Open Learning Environment (OLE) |
| **Supplementary readings** | - **Introduction to Autonomous Mobile Robots** *Roland Siegwart, Illah Reza Nourbakhsh and Davide Scaramuzza* MIT Press<br>- **Probabilistic Robotics** *Sebastian Thrun, Wolfram Burgard, Dieter Fox* MIT Press |

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| | - **Modern Robotics**<br>*Kevin Lynch and Frank C. Park*<br>Cambridge University Press<br>- **Rigid Body Dynamics Algorithms**<br>*Roy Featherstone*<br>Springer<br>- **Robotics - Modelling, Planning and Control**<br>*Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, Giuseppe Oriolo*<br>Springer |