

Polytechnic School
Master's degree in Robotics Engineering

Class LM-32
DEGREE REGULATION
General part

Art. 1 Premise and area of competence

This Regulation, in accordance with the Statute and the University Degree regulation (general part and special part), discipline the organisational aspects of the teaching activity of the Master's degree Course in Robotics Engineering, as well as any other subject devolved to it by other legislative and regulatory sources.

The Degree regulation of the Master's degree Course in Robotics Engineering is resolved, pursuant to article 18, paragraphs 3 and 4 of the University Degree regulation, general part, by the Degree Programme Board (DPB) of Robotics Engineering to the majority of the members and submitted for the approval of the Board of the reference Department (and the Boards of the possible associated Departments), after consultation with the Polytechnic School, with the prior favourable opinion of the Joint Committee of the School and the Department, if provided.

The resolutions of the DPB can also be taken in telematic mode according to the above-mentioned regulations and, in particular, of Article 14 "meetings with telematic mode" of the current General Regulation of the University (in force since 19/12/2018).

Art. 2 Admission requirements and procedures for verifying individual preparation

Admission to the Master's degree course in Robotics Engineering is subject to the possession of specific curriculum requirements and adequate personal preparation.

The curricular requirements for admission to the Master's Degree Course in Robotics Engineering are met if the student has a Degree or Master's Degree (ex D.M.M. 270/2004 obtained at an Italian University, or equivalent Degree ex Interministerial Decree of 9 July 2009), in the following classes:

- Class of Degrees in Information Engineering,
- Class of Degrees in Computer Science and Technology, - Class of Degrees in Industrial Engineering,

or similar qualifications at *Bachelor of Science* (B.Sc.) or *Master of Science* (M.Sc.) level recognised by foreign universities. In addition, the adequacy of personal preparation is verified, in particular in the following fields:

- mathematical analysis, geometry, physics, mathematical physics,
- fundamentals of electronics,
- fundamentals of computer science,
- fundamentals of automatic,
- fundamentals of mechanics,
- fundamentals of telecommunications,
- fundamentals of sensor and actuator technologies.

In the case of degrees other than those indicated above, the DPB verifies the presence of the curricular requirements or equivalent knowledge, based on the exams taken by the student in the degree course of origin, as well as the presence of any extra-curricular exams, internship activities and work experience gained.

An adequate knowledge of English is also required, not less than level B2.

In addition, students who do not have sufficient knowledge of the written and oral Italian language at the time of admission to the Master's Degree course must provide in their educational path for at least one of the two teaching units of Italian as a foreign language, provided for in the course's Training Offer.

Candidates' compliance with the curricular and individual requirements is verified by the Coordinator or by a specific Committee, which operates according to a protocol inspired by and similar to the selection protocol used for admission to the Erasmus+ *European Master on Advanced Robotics* (EMARO) and Japan-Europe *Master on Advanced Robotics*¹ (JEMARO) projects, of which the University of Genoa is a partner. The committee will assess each candidate:

1. the "academic potential" (e.g. average grade, class rank, GPA) up to a maximum of 40 points,
2. the relevance of the first level qualification, up to a maximum of 10 points,
3. the quality of the University that awarded the first level degree, up to a maximum of 20 points,
4. knowledge of the English language, in any case at a level not lower than B2 or equivalent scale, up to a maximum of 15 points,
5. letters of motivation, up to a maximum of 5 points,
6. letters of reference (not compulsory), up to a maximum of 5 points,
7. other aspects of the curriculum vitae (e.g. other qualifications, work experience, professional qualifications), up to a maximum of 5 points,
8. the gender, 0 points if male, 1 point if female.

Students who total at least 70 points will be admitted.

The Notice for Admission to the Polytechnic School's Master's Degree Courses and the website of the Master's Degree Course indicate: the composition of the Admission Committee, the required documentation and how to submit it, the evaluation criteria of the candidates, the results of the checks. The result of the admission procedure only includes the words "admitted", "not admitted".

The deadline for registration is December 31st of the first academic year of the course programme.

Art. 3 Training activities

The list of teaching units and other possible training activities, in the cohort 2020-2022, is given in the appropriate annex (Annex 1) which constitutes an integral part of this regulation. A responsible professor is identified for each teaching unit.

A professor is responsible for teaching whoever is in charge of teaching according to the law, i.e. the one to whom the relative Department Board has attributed the responsibility itself when assigning teaching tasks to professors.

The language used to provide training activities (lessons, exercises, workshops) shall be English.

¹ Sito web: <https://master-jemaro.ec-nantes.fr/>.

Art. 4 Enrolment in individual training activities

In accordance with Article 6 of the University Regulations for students, in order to enrol in individual training activities you must have a qualification which allows access to the university.

Art. 5 Curricula

The Master's degree Course in Robotics Engineering is not structured in curricula.

Art. 6 Total time commitment

The definition of the hourly fraction dedicated to lessons or equivalent teaching activities is established, for each teaching unit, by the DPB at the same time as defining the Degree Programme Table. In any case, we assume the following interval of variability between classroom hours/training credits (ECTS) equal to: $8 \div 10$, understanding by "classroom hours" the hours of lesson or assisted teaching activity.

The definition of the assumed total time commitment, reserved for personal study or other training activities of an individual type, is established, for each teaching unit, in the annex (Annex 1) to this regulation.

The director of the Department of Computer Science, Bioengineering, Robotics and Systems Engineering (DIBRIS) and the coordinator of the DPB shall be responsible for verifying compliance with the above provisions, also for the purposes of the publication of course programmes.

Art. 7 Study plans and prerequisites

Students must enroll full-time. Each student carries out his training activity considering the study plan prepared by the Master's degree course in Robotics Engineering, which is distinguished by years of the course programme and published in the Degree Programme Table. The study plan formulated by the student must contain an indication of the training activities, with the relative credits that he intends to achieve, provided by the official study plan for this teaching period, from a minimum of 45 credits up to a maximum of 65 provided in each year. The educational path of the student can be organised according with criteria of propaedeuticity, indicated in the Degree Programme Table.

The method and deadline for the presentation of the study plan are established annually by the Polytechnic School and reported in the Degree Programme Table.

In addition, specific rules and indications can be found on the University Degree Course sites² or on the specific site of the course.

The student may enter extra-curricular teaching units up to a maximum of 12 ECTS.

Students enrolled in the Master's Degree Course in Robotics Engineering who are part of the international study path are subject to some additional constraints regarding the compilation of their study plan. These restrictions can be found on the website of the University Degree Course.

Art. 8 Attendance and methods of carrying out teaching activities

The teaching units may take the form of:

- lectures, including distance learning by telematic means;
- practical exercises;
- laboratory exercises.

The attendance to the lessons and to other forms of training activity is compulsory. The students must attend the lectures, exercises and workshops, according to the methods indicated in the Degree Programme Table. The DPB may exempt the student from the obligation to attend, in whole or in part, if documented reasons are given. The schedule of classes is divided into semesters. As a rule,

² Website: <https://courses.unige.it/10635>.

the semester is divided into at least 12 weeks of lesson plus at least 4 weeks overall for verification tests and profit exams.

The period for profit exams ends with the beginning of the lessons of the following semester.

The lesson schedule for the entire academic year is published on the Course of Study's website before the start of the lessons of the academic year. The schedule of classes guarantees the possibility of attendance based on the years of the course programme provided for by the current Degree Programme Table.

Art. 9 Examinations and other profit exams

Profit exams can be carried out in written, oral, or written and oral, according to the methods indicated in the sheets of each teaching unit published on the website of the Master's degree course in Robotics Engineering.

As a rule, each teaching unit provides for assessments of preparation during the semester of lessons (hereinafter referred to as *continuous assessment*), the result of which contributes to the formation of the grade of the final profit exam. For each lesson, the portion of the final grade reserved for continuous assessment is declared in the teaching sheets published on the website of the Master's Degree Course in Robotics Engineering.

The examinations are conducted in English. The grade assignment, in all the EMARO and JEMARO consortium offices, is based on 100 (with a sufficiency of 60). For the purposes of registration in the Italian system, the grade in base 100 is transformed into grade in base 30, taking into account the European Credit Transfer and accumulation System³ (ECTS) framework.

On request, specific learning verification arrangements may be provided which take into account the needs of disabled students and students with specific learning disorders (D. S. A.), in accordance with art. 29 paragraph 4 of the University Degree regulation.

In the case of teaching units structured in modules with several professors, they participate collegially in the overall evaluation of the student's profit.

The calendar of profit exams is established by October 31st for the first semester of the following academic year and by March 31th for the second semester of the current academic year, and it is published on the website of the Master's Degree Course. The calendar of any intermediate verification tests is established by the DPB and communicated to the students at the beginning of each teaching cycle. The calendar of examinations, as an exception to the University Degree regulation, provides for a reduced number of sessions, in line with that of the other foreign Masters of the EMARO and JEMARO projects.

Examinations are held in periods of interruption of classes. All profit examinations of training activities must be passed by the student at least twenty days before the expected date for taking the final examination.

The result of the examination, with the vote obtained, is verbalized in accordance with art. 29 of the University Degree regulation.

Art. 10 Recognition of credits

The Board Degree Programme decides on the approval of applications for change or transfer from another degree course of the university or other universities in accordance with the rules provided for in the University Degree regulation, art. 21. The DPB also decides the recognition, as training credits, for a maximum number of 12 ECTS, of professional knowledge and skills certified in accordance with the current legislation.

³ Sito web: https://ec.europa.eu/education/resources-and-tools/european-credit-transfer-and-accumulation-systemects_en.

The evaluation of applications for change will take into account the didactic specificities and the actuality of the educational content of the individual exams taken, reserving to establish from time to time any forms of verification and supplementary exams.

Within the framework of the national and regional legislation on alternance education/work, it is possible for the course of study to provide, for selected students, learning paths that also take into account work experience carried out at companies under contract.

Art. 11 Mobility, studies abroad, international exchanges

The DPB strongly supports the student mobility, in particular through participation to mobility and international exchange programmes. Periods of study abroad are also valued by means of a special assessment which is taken into account when determining the degree mark, as described in Article 12 below. The DPB shall ensure, in accordance with the rules in force, the recognition of the training credits obtained within these programmes and shall organise the training activities as appropriate in such a way as to make these activities easier and effective.

The DPB recognizes enrolled students, who have regularly completed a period of study abroad, the exams taken off-site and the achievement of the related credits with which the student intends to replace the exams of his own study plan.

For the purposes of the recognition of these examinations, the student at the time of the compilation of the plan of training activities, he intends to follow at the University abroad, must produce suitable documentation proving the equivalence of content between the teaching unit abroad and the teaching unit that intends to replace taught in the Master's degree Course in Robotics Engineering. Equivalence shall be evaluated by the DPB.

The conversion of marks will take place according to criteria approved by the DPB, in accordance with EMARO and JEMARO grade system and European ECTS system.

Students enrolled in the Master's Degree Course in Robotics Engineering who are particularly deserving and who pass all the first year's exams at a time and in a manner consistent with those established by the EMARO consortium may apply for the EMARO double degree course. The decision on their admission is taken by the EMARO *international board*, which establishes each year the number of available positions and admission on the basis of the ranking, calculated on the basis of the marks obtained in the first year's exams. Such admission implies the obligation to attend the entire second year in one of the current foreign universities of the EMARO consortium, with the payment of the registration fees provided for at the foreign university where the second year takes place. EMARO students are to be considered enrolled in the Master's Degree Course in Robotics Engineering for the entire duration of their studies, including during their stay at the foreign university where they are in their second year.

The mobility of students of the international JEMARO consortium is compulsory and is limited to Keio University, partner of the JEMARO consortium. JEMARO students are to be considered enrolled in the Master's Degree Course in Robotics Engineering for the entire duration of their studies, including during their stay at Keio University.

Art. 12 Procedures for the final examination

The final examination consists in the discussion of a written thesis, aimed at ascertaining the candidate's technical-scientific and professional preparation.

For the purposes of obtaining a Master's Degree in Robotics Engineering, the final examination consists of the writing of a theoretical, experimental or applicative thesis, elaborated by the student in an original way under the guidance of one or more supervisors, on subjects defined as relevant to a discipline for which the candidate has passed the exam. The thesis must in any case be coherent with the arguments discussed during the Master's degree in Robotics Engineering.

The thesis must reveal the student's ability to deal with research and/or application issues. The thesis must consist of a project and/or the development of an application that proposes innovative solutions with respect to the state of the art.

The thesis must also reveal preparation in the disciplines characterising the Master's Degree in Robotics Engineering, a correct use of sources and bibliography, systematic and argumentative skills, clarity in the exposition, design and experimental skills, critical skills.

The thesis must be written in English. In case of use of another language of the European Union, the authorization of the DPB, the translation of the title and the writing of an extensive summary in English is required. At least one DPB lecturer must be present among the supervisors, or a member appointed by the DPB of the relevant Department or an associated Department.

The Committee for the final examination is composed of at least five members, the majority of whom must be tenured professors and researchers and it is appointed by the Director of the DIBRIS Department or by the delegated coordinator of the Course of Study.

The procedure for the final examination consists of the oral presentation of the thesis by the student to the Final Examination Committee, followed by a discussion of any questions raised by the members of the Committee.

The degree grade is determined by the Committee, by applying a variation to the weighted average of the marks obtained in the exams relating to training activities that require a final vote, taking as weight the number of credits associated with the individual training activity. As a result of a series of evaluations, the Committee assigns the candidate a score for the final test.

The thesis grade will be awarded taking into account the evaluation of the thesis and its discussion by the candidate, whether the candidate will graduate quickly, and whether or not the candidate has acquired credits abroad. In particular:

1. the Committee assigns a thesis grade A on the basis of 100 as evaluation of the thesis and its discussion, and then returns it to an A' value in the real numerical range from 0 to N;
2. the Committee adds to the thesis grade A' expressed on the basis of N a numerical bonus B inversely proportional to the time elapsed from the first useful date on which the candidate could have graduated, until the December graduation session of the second A.A. in progress;
3. the Committee also adds to the cumulative thesis grade A'+B a numerical bonus C which is positively influenced by the fact that the student has spent periods for study and/or thesis abroad.

The sum of A, B and C constitutes the overall thesis grade. The graduation grade is calculated by adding the thesis grade to the weighted average of the exam grades based on 110.

The numerical bonus B makes it possible to enhance a student's ability to graduate quickly, while the numerical bonus C makes it possible to enhance periods of study abroad. The numerical values of B and C are reassessed by the DPB at the beginning of each Academic Year and published on the website of the Degree Course in Robotics Engineering.

Art. 13 Guidance services and tutoring

The Polytechnic School, in agreement with the DIBRIS Department, organizes and manages a tutoring service for the welcome and support of students, in order to prevent dispersion and delay in studies and to promote a profitable active participation in university life in all its forms.

The DPB identifies within it a number of tutors in proportion to the number of students enrolled. The names of the tutors can be found on the website of the Master's degree course in Robotics Engineering.

Art. 14 Verification of obsolescence of credits

Credits acquired within the framework of the Master's degree course in Robotics Engineering are valid for 6 years. After the indicated period, the credits must be validated by special resolution if the DPB recognises the non-obsolescence of the related educational contents. If the DPB recognizes the obsolescence of even a single part of the relative educational content, the DPB itself establishes the supplementary tests that must be taken by the student, defining the topic and the methods of verification.

Once the required tests have been passed, the DPB validates the credits acquired with a resolution. If the related training activity provides for a vote, it may be varied from the one previously obtained, on a proposal from the Examination Committee which carried out the verification.

Art. 15 Degree Programme Table

The DIBRIS Department, after consulting the Polytechnic School, approves and publishes annually the Degree Programme Table. In the Degree Programme Table are indicated the main provisions of the didactic system and the degree regulation of the Master's degree course, to which additional information may be added.

The Degree Programme Table of the Master's degree course contains the list of the teaching units activated for the academic year in question. Individual teaching units' sheets are published on the website of the degree course.

This Degree regulation was approved by resolution of the Board of the Master's Degree Course in Robotics Engineering on 27th March 2020.

Annex 1 to the Degree regulation of the Master's degree course in Robotics Engineering
List of possible training activities and related training objectives

Academic year	Teaching unit's code	Teaching unit in Italian	Teaching unit in English	ECTS (credits)	SSD (disciplinary-scientific area)	Type	Area	Language	Prerequisites	Training objectives	Hours reserved for assisted teaching activities	Hours reserved for personal study
1	52164	ITALIAN LANGUAGE (FOR FOREIGN STUDENTS) - LONG	ITALIAN LANGUAGE (FOR FOREIGN STUDENTS) - LONG	5	L-FIL-LET/12	ELECTIVE LEARNING ACTIVITY	Student's elective learning activity	Italian (English on demand)	-	The course allows the student to achieve a sufficient oral and written comprehension of the local language, as well as an introduction to country culture.	50	75
1	56846	MODELING AND CONTROL OF MANIPULATORS	MODELING AND CONTROL OF MANIPULATORS	6	ING-INF/04	CORE LEARNING ACTIVITY	Computer science engineering	English	-	This course presents the fundamentals of the modeling and control techniques of serial manipulators. Topics include robot architectures, geometric modeling, kinematic modeling, dynamic modeling and its applications, as well as the classical PID controller and computed torque controller.	48	102
1	80158	HUMAN COMPUTER INTERACTION	HUMAN COMPUTER INTERACTION	5	ING-INF/05	CORE LEARNING ACTIVITY	Computer science engineering	English	-	The course faces theories and techniques for the design of interactive systems and multimodal systems.	40	85
1	80169	REAL-TIME OPERATING SYSTEMS	REAL-TIME OPERATING SYSTEMS	5	ING-INF/05	CORE LEARNING ACTIVITY	Computer science engineering	English	-	By attending the course, the student will learn how to deal with issues concerning real-time applications and real-time operative systems, real-time design and programming, embedded systems.	40	85
1	80181	CONTROL OF LINEAR MULTI-VARIABLE SYS.	CONTROL OF LINEAR MULTI-VARIABLE SYS.	5	ING-INF/04	CORE LEARNING ACTIVITY	Computer science engineering	English	-	The aim of the course is to give a methodology for the design of a control law for multivariable linear time invariant systems (MIMO LTI systems)	40	85
1	80183	MECHANICAL DESIGN METHODS IN ROBOTICS	MECHANICAL DESIGN METHODS IN ROBOTICS	5	ING-IND/13	ELECTIVE LEARNING ACTIVITY	Student's elective learning activity	English	-	This course presents the overview of the design process-specification, conceptual design, product design. The	40	85

										students will learn basic principles of industrial robot design.		
1	80186	SYSTEM IDENTIFICATION	SYSTEM IDENTIFICATION	5	ING-INF/04	ELECTIVE LEARNING ACTIVITY	Student's elective learning activity	English	-	The goal of the course is to provide methodologies and tools for designing systems' models to be used for control, estimation, diagnosis, prediction, etc. Different identification methods are considered, both in a "black box" context (where the structure of the system is unknown), as well as in a "grey box" (uncertainty on parameters) one. Methods are provided for choosing the complexity of the models, for determining the values of their parameters, and to validate them. Moreover, state estimation problems are addressed and their connections with control and identification are considered.	40	85
1	80514	MECHANICS OF MECHANISMS AND MACHINES	MECHANICS OF MECHANISMS AND MACHINES	5	ING-IND/13	RELATED OR SUPPLEMENTARY LEARNING ACTIVITY	Related or supplementary learning activity	English	-	Fundamentals of theory of mechanisms and machines: synthesis, analysis, modelling, singularities. Kinematics and elements of dynamics. Serial and parallel architectures. Compliant mechanisms. Architectures for robotics. The Lie group of rigid body displacement. Screw theory.	40	85
1	86733	OPTIMISATION TECHNIQUES	OPTIMISATION TECHNIQUES	5	MAT/09	ELECTIVE LEARNING ACTIVITY	Student's elective learning activity	English	-	The lecture presents different theoretical and computational aspects of a wide range of optimization methods for solving a variety of problems in engineering and robotics.	40	85
1	86735	COMPUTER VISION	COMPUTER VISION	5	INF/01	ELECTIVE LEARNING ACTIVITY	Student's elective learning activity	English	-	The course aims at providing knowledge on theory and tools on the basics of Computer Vision, for the extraction of semantic and geometric information about a scene from	40	85

										an image or a sequence of images. Topics of interest include: camera models and image formation; camera calibration; connection between 2D images and 3D scene structures; image processing basics as image filtering, local features extraction (edge, corner, blob), including the use of multi-scale image representations; image matching, with reference to classification and retrieval problems; stereo vision and scene depth estimation; motion detection in image sequences, including change detection and optical flow estimation.		
1	86736	ADVANCED AND ROBOT PROGRAMMING	ADVANCED AND ROBOT PROGRAMMING	5	ING-INF/05	CORE LEARNING ACTIVITY	Computer science engineering	English	-	The goal of the course is to give the students the fundamentals of POSIX programming, concurrent programming, inter-process communication (i.e., interrupts, signals, pipes, publish/subscribe). The course leverages the ROS environment to build up advanced examples and use cases.	40	85
1	86738	NONLINEAR CONTROL TECHNIQUES	NONLINEAR CONTROL TECHNIQUES	5	ING-INF/04	CORE LEARNING ACTIVITY	Computer science engineering	English	-	Students are introduced to basic concepts from differential geometry and differential algebra which are instrumental for controllability and observability criteria. The course features control algorithms as the computed torque, popular in robotics, or feedback linearization. Basics from Lyapunov theory are reviewed and applied to control Lyapunov functions which are instrumental for practical robust control algorithms as sliding modes or backstepping.	40	85

1	86739	MOBILE ROBOTS	MOBILE ROBOTS	5	ING-INF/04	CORE LEARNING ACTIVITY	Computer science engineering	English	-	The class first develops the kinematic modeling and motorization of mobile robots, illustrated by the full study of the differential drive robot. Then localization based on the Extended Kalman Filter is addressed, is illustrated by a lab which uses real data and presents a tuning methodology. Observability issues are also addressed, with practical examples. Planning methods applicable to mobile robots are studied, in particular potential field methods and the Rapidly exploring Random Tree. Control then focuses on direct applications to mobile robots: static and dynamic feedback control and Lyapunov based control, illustrated on the case of the differential drive robot.	40	85
1	86746	ITALIAN LANGUAGE (FOR FOREIGN STUDENTS) - BRIEF	ITALIAN LANGUAGE (FOR FOREIGN STUDENTS) - BRIEF	4	L-FIL-LET/12	ELECTIVE LEARNING ACTIVITY	Student's elective learning activity	Italian (English on demand)	-	The course allows the student to achieve a sufficient oral and written comprehension of the local language, as well as an introduction to country culture.	40	60
1	86805	SOFTWARE ARCHITECTURES FOR ROBOTICS	SOFTWARE ARCHITECTURES FOR ROBOTICS	5	ING-INF/05	CORE LEARNING ACTIVITY	Computer science engineering	English	-	A robot is a multi-purpose, multi-form and multi-function machine. It exhibits completely new and unique characteristics with respect to what it is for, how it is structured and what it is able to do. In order to cope with this diversity in form and function, software architectures for robots must be grounded on top of a model enforcing flexibility and efficiency well beyond those developed in other domain applications.	40	85
1	86928	MACHINE LEARNING FOR ROBOTICS I	MACHINE LEARNING FOR ROBOTICS I	5	INF/01	ELECTIVE LEARNING ACTIVITY	Student's elective learning activity	English	-	The goal of the class is to present Artificial Neural Networks and other well-known Machine Learning techniques as systems for solving supervised and	40	85

										unsupervised learning problems, with a specific emphasis on Robotics applications. Such learning systems can be applied to pattern recognition, function approximation, time-series prediction and clustering problems. Some mention will be made to the use of ANNs as static systems for information coding, and dynamical systems for optimization and identification.		
1	104729	RESEARCH TRACK 1	RESEARCH TRACK 1	5		OTHER ACTIVITY	Training and Orientation Traineeships	English	-	Robotics is a multi-disciplinary field characterised by a high degree of research. Research Track 1 and Research Track 2 are aimed at developing a series of must-have know-how and expertise that any researcher in Robotics must be acquainted to. In particular, Research Track 1 will lay the basis of software development for robots, as well as practical insights in robot architectures. These knowledges will be of fundamental importance for later courses and the practice classes therein.	25	100
1	104730	RESEARCH TRACK 2	RESEARCH TRACK 2	5		OTHER ACTIVITY	Training and Orientation Traineeships	English	-	Robotics is a multi-disciplinary field characterised by a high degree of research. Research Track 1 and Research Track 2 are aimed at developing a series of must-have know-how and expertise that any researcher in Robotics must be acquainted to. In particular, Research Track 2 will consider subjects related to project design, development, assessment, reporting, as well as ancillary knowledge as experimental methodologies, data visualisation, bibliography research, pitch presentations.	25	100

1	104731	ARTIFICIAL INTELLIGENCE FOR ROBOTICS II	ARTIFICIAL INTELLIGENCE FOR ROBOTICS II	5	ING-INF/05	ELECTIVE LEARNING ACTIVITY	Student's elective learning activity	English	-	Artificial Intelligence for Robotics 2 is the logic follow-up of Artificial Intelligence for Robotics 1. In this course, the students will be introduced to concepts related to knowledge representation and reasoning (ontologies, description logics, OWL, subsumption, instance checking), planning for hybrid domains (with a particular focus on discrete/continuous domains), as well as AI-based robot motion algorithms (es., RRTs, probabilistic roadmaps, belief-space planning).	40	85
1	104734	ARTIFICIAL INTELLIGENCE FOR ROBOTICS I	ARTIFICIAL INTELLIGENCE FOR ROBOTICS I	5	ING-INF/05	CORE LEARNING ACTIVITY	Computer science engineering	English	-	The goal of the course is to provide the foundations of knowledge-based intelligent autonomous agents.	40	85
1	105038	SIGNAL PROCESSING IN ROBOTICS	SIGNAL PROCESSING IN ROBOTICS	5	ING-IND/31	ELECTIVE LEARNING ACTIVITY	Student's elective learning activity	English	-	Signal Processing in Robotics provides the necessary background for the analysis of data typically used in robots, which is useful for many other subjects in the course. Different information types, as well as approaches, techniques, and algorithms, will be introduced.	40	85
2	52164	ITALIAN LANGUAGE (FOR FOREIGN STUDENTS) - LONG	ITALIAN LANGUAGE (FOR FOREIGN STUDENTS) - LONG	5	L-FIL-LET/12	RELATED OR SUPPLEMENTARY LEARNING ACTIVITY	Related or supplementary learning activity	Italian (English on demand)	-	The course allows the student to achieve a sufficient oral and written comprehension of the local language, as well as an introduction to country culture.	50	75
2	60452	MASTER THESIS	MASTER THESIS	30		FINAL EXAMINATION	Final examination	English	-	The MSc thesis must be elaborated by the student in an original fashion and under the guidance of one or more supervisors. It will have to exhibit an appropriate understanding of fundamental principles, an adequate use of resources and bibliography, as well as rational and argumentation-related capabilities. It must be	0	750

										developed with a clear English language, be based on well-defined design and experimental practices, as well as on critical thinking.		
2	66044	FLEXIBLE AUTOMATION	FLEXIBLE AUTOMATION	4	ING-IND/13	RELATED OR SUPPLEMENTARY LEARNING ACTIVITY	Related or supplementary learning activity	English	-	<p>This course provides a general intersectoral introduction to applications, scopes and development of flexible automation, including robotics, for industrial and non-industrial sectors. Technologies, means and methods, socio-economic issues related with different domains are presented and discussed.</p> <p>In greater detail, design and development techniques are proposed for intelligent flexible automation of industrial production systems with a view to Factory 4.0.</p>	32	68
2	80186	SYSTEM IDENTIFICATION	SYSTEM IDENTIFICATION	4	ING-INF/04	CORE LEARNING ACTIVITY	Computer science engineering	English	-	<p>The goal of the course is to provide methodologies and tools for designing systems' models to be used for control, estimation, diagnosis, prediction, etc. Different identification methods are considered, both in a "black box" context (where the structure of the system is unknown), as well as in a "grey box" (uncertainty on parameters) one. Methods are provided for choosing the complexity of the models, for determining the values of their parameters, and to validate them. Moreover, state estimation problems are addressed and their connections with control and identification are considered.</p>	32	68
2	80186	SYSTEM IDENTIFICATION	SYSTEM IDENTIFICATION	4	ING-INF/04	RELATED OR SUPPLEMENTARY	Related or supplementary	English	-	<p>The goal of the course is to provide methodologies and tools for designing systems'</p>	32	68

						NTARY LEARNING ACTIVITY	learning activity			models to be used for control, estimation, diagnosis, prediction, etc. Different identification methods are considered, both in a “black box” context (where the structure of the system is unknown), as well as in a “grey box” (uncertainty on parameters) one. Methods are provided for choosing the complexity of the models, for determining the values of their parameters, and to validate them. Moreover, state estimation problems are addressed and their connections with control and identification are considered.		
2	80188	AMBIENT INTELLIGENCE	AMBIENT INTELLIGENCE	4	ING-INF/05	RELATED OR SUPPLEMENTARY LEARNING ACTIVITY	Related or supplementary learning activity	English	-	The goal of the course is to enable students to understand the Ambient Intelligence computing paradigm, which envisions a world where people (and possibly robots) are surrounded by intelligent sensors/actuators and interfaces embedded in the everyday objects around them.	32	68
2	80188	AMBIENT INTELLIGENCE	AMBIENT INTELLIGENCE	4	ING-INF/05	CORE LEARNING ACTIVITY	Computer science engineering	English	-	The goal of the course is to enable students to understand the Ambient Intelligence computing paradigm, which envisions a world where people (and possibly robots) are surrounded by intelligent sensors/actuators and interfaces embedded in the everyday objects around them.	32	68
2	80190	EMBEDDED SYSTEMS	EMBEDDED SYSTEMS	4	ING-INF/04	RELATED OR SUPPLEMENTARY LEARNING ACTIVITY	Related or supplementary learning activity	English	-	This course presents the fundamentals of embedded systems. After a brief review of the most relevant architectures, the course focuses on microcontroller programming for control applications, with a particular attention on	32	68

										peripheral configuration, real time and event-based programming techniques.		
2	80190	EMBEDDED SYSTEMS	EMBEDDED SYSTEMS	4	ING-INF/04	CORE LEARNING ACTIVITY	Computer science engineering	English	-	This course presents the fundamentals of embedded systems. After a brief review of the most relevant architectures, the course focuses on microcontroller programming for control applications, with a particular attention on peripheral configuration, real time and event-based programming techniques.	32	68
2	80192	ADVANCED MODELLING AND SIMULATION TECHNIQUES FOR ROBOTS	ADVANCED MODELLING AND SIMULATION TECHNIQUES FOR ROBOTS	4	ING-IND/13	RELATED OR SUPPLEMENTARY LEARNING ACTIVITY	Related or supplementary learning activity	English	-	The present course is intended for providing the students with the fundamental mechatronic concepts and related modelling and simulation technologies enabling the realization of reconfigurable, soft, dexterous manipulating and mobile, modular robotic structures. Modelling and simulation of distributed sensorial, actuation and control systems are as well included in the course educational targets.	32	68
2	86732	RESEARCH METHODOLOGY	RESEARCH METHODOLOGY	1	ING-IND/13	RELATED OR SUPPLEMENTARY LEARNING ACTIVITY	Related or supplementary learning activity	English	-	This course is intended to provide the student with the necessary skills and tools to carry out and present a research topic. It presents the profession of university staff, researchers in research institutions, and in R&D departments in enterprises and how to apply for them. This course includes also the beginning of the bibliographical study and collect information part for the MSc thesis topic.	8	17
2	86746	ITALIAN LANGUAGE (FOR FOREIGN STUDENTS) - BRIEF	ITALIAN LANGUAGE (FOR FOREIGN STUDENTS) - BRIEF	4	L-FIL-LET/12	RELATED OR SUPPLEMENTARY LEARNING ACTIVITY	Related or supplementary learning activity	Italian (English on demand)	-	The course allows the student to achieve a sufficient oral and written comprehension of the local language, as well as an introduction to country culture.	40	60

2	94864	EXPERIMENTAL ROBOTICS LABORATORY	EXPERIMENTAL ROBOTICS LABORATORY	4	ING-INF/04	CORE LEARNING ACTIVITY	Computer science engineering	English	-	The course's aim is to put into action the theoretical knowledge acquired in other courses, providing some robotic setups for specific implementations. The course will also include methodological information on experiments design and validation of results.	32	68
2	94864	EXPERIMENTAL ROBOTICS LABORATORY	EXPERIMENTAL ROBOTICS LABORATORY	4	ING-INF/04	RELATED OR SUPPLEMENTARY LEARNING ACTIVITY	Related or supplementary learning activity	English	-	The course's aim is to put into action the theoretical knowledge acquired in other courses, providing some robotic setups for specific implementations. The course will also include methodological information on experiments design and validation of results.	32	68
2	94866	SOCIAL ROBOTICS	SOCIAL ROBOTICS	4	ING-INF/05	CORE LEARNING ACTIVITY	Computer science engineering	English	-	The objective of the course is to make students aware about the most relevant issues in the fields of social robotics, including: verbal and nonverbal human-robot interaction; cultural factors in the design of social robots; anthropomorphic and zoomorphic robots and robot behaviours; sensors for human-robot interaction; methodology and constraints in making experiments with robots and human participants; application scenarios. The student will face these problems both from a theoretical perspective and through practical assignments, by exploring in depth one of the topics above on real robots for social interaction.	32	68
2	94866	SOCIAL ROBOTICS	SOCIAL ROBOTICS	4	ING-INF/05	RELATED OR SUPPLEMENTARY LEARNING ACTIVITY	Related or supplementary learning activity	English	-	The objective of the course is to make students aware about the most relevant issues in the fields of social robotics, including: verbal and nonverbal human-robot interaction; cultural factors in the design of social robots; anthropomorphic and	32	68

										zoomorphic robots and robot behaviours; sensors for human-robot interaction; methodology and constraints in making experiments with robots and human participants; application scenarios. The student will face these problems both from a theoretical perspective and through practical assignments, by exploring in depth one of the topics above on real robots for social interaction.		
2	98454	BIOMEDICAL ROBOTICS	BIOMEDICAL ROBOTICS	4	ING-INF/06	RELATED OR SUPPLEMENTARY LEARNING ACTIVITY	Related or supplementary learning activity	English	-	The purpose of this course is to provide a perspective on robotic technologies applied to (and inspired by) themes of biomedical research and practice.	32	68
2	98457	COOPERATIVE ROBOTICS	COOPERATIVE ROBOTICS	4	ING-INF/04	RELATED OR SUPPLEMENTARY LEARNING ACTIVITY	Related or supplementary learning activity	English	-	The goal of the course is to first introduce a modern task-priority based control of robotic systems such as dual arm robots, mobile manipulators, floating underwater vehicle-manipulator systems, which are all characterized by a high number of degrees of freedom. The framework is extended to the case where multiple robots need to work together, for example to manipulate and transport objects cooperatively.	32	68
2	98457	COOPERATIVE ROBOTICS	COOPERATIVE ROBOTICS	4	ING-INF/04	CORE LEARNING ACTIVITY	Computer science engineering	English	-	The goal of the course is to first introduce a modern task-priority based control of robotic systems such as dual arm robots, mobile manipulators, floating underwater vehicle-manipulator systems, which are all characterized by a high number of degrees of freedom. The framework is extended to the case where multiple robots need to work together, for example to manipulate and transport objects cooperatively.	32	68

2	104737	VIRTUAL REALITY FOR ROBOTICS	VIRTUAL REALITY FOR ROBOTICS	4	ING-INF/05	CORE LEARNING ACTIVITY	Computer science engineering	English	-	Starting from the knowledge on the fundamentals of graphics, modeling and animation of 3D digital objects, the aim of the course is to get to the programming skills necessary to build applications and systems based on simulation in virtual / mixed / augmented / extended reality (VR / AR / MR / XR). The fundamental objectives of this course are to make students aware of the necessary interdisciplinarity of VR for Robotics: from mobile programming to biomechanics, sensory perception, humanoid robotics and video games, in order to manage complex interactions between simulated and / or physical objects and actors (both FPV first-person view and TPV third-person view).	32	68
2	104737	VIRTUAL REALITY FOR ROBOTICS	VIRTUAL REALITY FOR ROBOTICS	4	ING-INF/05	RELATED OR SUPPLEMENTARY LEARNING ACTIVITY	Related or supplementary learning activity	English	-	Starting from the knowledge on the fundamentals of graphics, modeling and animation of 3D digital objects, the aim of the course is to get to the programming skills necessary to build applications and systems based on simulation in virtual / mixed / augmented / extended reality (VR / AR / MR / XR). The fundamental objectives of this course are to make students aware of the necessary interdisciplinarity of VR for Robotics: from mobile programming to biomechanics, sensory perception, humanoid robotics and video games, in order to manage complex interactions between simulated and / or physical objects and actors (both FPV first-person	32	68

										view and TPV third-person view).		
2	104748	LINGUISTICS AND PHYLOSOPHY OF LANGUAGE	LINGUISTICS AND PHYLOSOPHY OF LANGUAGE	4	M-FIL/05	RELATED OR SUPPLEMENTARY LEARNING ACTIVITY	Related or supplementary learning activity	English	-	In Robotics, a computational perspective on the study of language is gaining much attention both in research and in real-world applications, such as vocal assistants, smart speakers, intelligent avatars. However, often these devices do not exploit the whole corpus of knowledge developed in the past decades in linguistics. This subject will provide students with solid theoretical foundations on the subject.	32	68
2	104749	PSYCHOLOGY OF PERCEPTION AND ACTION	PSYCHOLOGY OF PERCEPTION AND ACTION	4	M-PSI/01	RELATED OR SUPPLEMENTARY LEARNING ACTIVITY	Related or supplementary learning activity	English	-	For a robot, perception and actions are fundamental, defining features of stereotyped or purposive behaviour. Especially when interacting with humans, robots must be capable of employing mental models of the human they are interacting with, perceiving the environment and their actions using common, shared categories, and act in a credible manner. This subject will provide advanced knowledge and theoretical insights about these matters.	32	68
2	104855	MACHINE LEARNING FOR ROBOTICS II	MACHINE LEARNING FOR ROBOTICS II	4	ING-INF/05	RELATED OR SUPPLEMENTARY LEARNING ACTIVITY	Related or supplementary learning activity	English	-	This course, which is made up of two separate modules, aims at providing students with theoretical insights into machine learning and data analysis, with a specific emphasis on Robotics-related use cases.	0	0
2	104855	MACHINE LEARNING FOR ROBOTICS II	MACHINE LEARNING FOR ROBOTICS II	4	ING-INF/05	CORE LEARNING ACTIVITY	Computer science engineering	English	-	This course, which is made up of two separate modules, aims at providing students with theoretical insights into machine learning and data analysis, with a specific emphasis on Robotics-related use cases.	0	0

2	86798	MACHINE LEARNING AND DATA ANALYSIS	MACHINE LEARNING AND DATA ANALYSIS	3	ING-INF/05	RELATED OR SUPPLEMENTARY LEARNING ACTIVITY	Related or supplementary learning activity	English	-	Students will be provided with advanced skills related to machine learning and data analysis with particular reference to the statistical learning theory and its application to real world problems. Students will learn practical and theoretical insights on machine learning and data analysis methodologies.	24	51
2	86798	MACHINE LEARNING AND DATA ANALYSIS	MACHINE LEARNING AND DATA ANALYSIS	3	ING-INF/05	CORE LEARNING ACTIVITY	Computer science engineering	English	-	Students will be provided with advanced skills related to machine learning and data analysis with particular reference to the statistical learning theory and its application to real world problems. Students will learn practical and theoretical insights on machine learning and data analysis methodologies.	24	51
2	104856	ROBOTICS USE CASES	ROBOTICS USE CASES	1	ING-INF/05	RELATED OR SUPPLEMENTARY LEARNING ACTIVITY	Related or supplementary learning activity	English	-	In this module, students will focus on the study of use cases specifically related to Robotics, on the basis of methodologies and insights discussed in the accompanying main module.	8	17
2	104856	ROBOTICS USE CASES	ROBOTICS USE CASES	1	ING-INF/05	CORE LEARNING ACTIVITY	Computer science engineering	English	-	In this module, students will focus on the study of use cases specifically related to Robotics, on the basis of methodologies and insights discussed in the accompanying main module.	8	17
2	80190	EMBEDDED SYSTEMS	EMBEDDED SYSTEMS	4	ING-INF/04	CORE LEARNING ACTIVITY	Computer science engineering	English	-	This course presents the fundamentals of embedded systems. After a brief review of the most relevant architectures, the course focuses on microcontroller programming for control applications, with a particular attention on peripheral configuration, real time and event-based programming techniques.	32	68