POLYTECHNIC SCHOOL
Master's degree in *Robotics Engineering* Class LM-32
DEGREE REGULATION - General part

INDEX

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 organizational 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 25, paragraphs 1 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 forthe 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 background

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

The curricular requirements for admission to the Master's Degree Course in Robotics Engineering aremet 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 IndustrialEngineering,

or similar qualifications at *Bachelor of Science* (B.Sc.) or *Master of Science* (M.Sc.) level recognisedby foreign universities.
The equivalence of the foreign qualification is determined by an analysis of the academic qualification, the candidate's CV and the Transcript of Records.
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 courseof origin, as well as the presence of any extra-curricular exams, internship activities and work experience gained.

Adequate knowledge of the English language is also required, not less than level B2 or equivalent, verified by certification, obtained no more than 3 years beforehand or, in the absence of such certification, by passing the B2 test provided by the Language Skills Development Sector (of the University). The language requirement is also met in case the candidate has a degree in English, which must be certified by an official document or letter from the university that offered the three-year degree, showing that the studies were carried out in English.

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 leastone 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 for each candidate:

1. the "academic potential" (e.g. average grade, class rank, GPA),
2. the relevance of the first level qualification,
3. the quality of the University that awarded the first level degree,
4. knowledge of the English language, in any case at a level not lower than B2 or equivalentscale,
5. letters of motivation,
6. letters of reference (not mandatory),
7. other aspects of the curriculum vitae (e.g. other qualifications, work experience, professional qualifications).

The Notice for Admission to the Polytechnic School's Master's Degree Courses and the website of the

[1] https://master-jemaro.ec-nantes.fr/

Master's Degree Course[2] 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 deadline for registration is January 10th of the first academic year of the course programme.

For applicants from non-EU countries, with foreign residence and having a diploma not issued by an EU country, the application procedure for checking eligibility takes place on an online portal, annually published on institutional web sites and on the Degree Course web site, according to a timetable and deadlines established annually and duly communicated to students.
Following the upload of the required documentation on the portal, the following checks will be carried out:

- completeness of documents
- verification of curricular requirements
- verification of knowledge of the English language

Applicants who pass these checks proceed to a two-stage assessment:

- credentials evaluation
- assessment of the candidate

After these assessments, the outcome of the admission procedure will be marked "admitted" or "conditionally admitted upon graduation".

Art. 3. Training activities

The list of teaching units and other possible training activities, in the cohort 2022-2024, 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., theone 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.

Art. 4. Enrolment in individual training activities

In accordance with Article 5 of the University Regulations for students, in order 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/trainingcredits (ECTS) equal to: 8 ÷ 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

[2] https://courses.unige.it/10635

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 compliancewith the above provisions.

Art. 7. Study plans and prerequisites

Students must enrol full-time.

Each student carries out his training activity considering the study planprepared 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 bythe student must contain an indication of the training activities, with the relative credits that he intendsto achieve, provided by the official study plan for this teaching period, from a minimum of 45 creditsup to a maximum of 65 provided in each year. The educational path of the student can be organised according with criteria of propaedeutic subjects, 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 provisions may be published on the Master's Degree Course website or communicated directly to students, including those relating to subsequent requests for changes to the study plan.

The student may enter extra-curricular teaching units up to a maximum of 12 ECTS. Those ECTS are not taken into account in the total amount of ECTS nor for the global average.

Students enrolled in the Master's Degree Course in Robotics Engineering who are part of either international study paths, EMARO or JEMARO, are subject to some additional constraints regarding the compilation of theirstudy 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;
- thematic seminars.

The attendance to the lessons and to other forms of training activity is compulsory. The students must attend the lectures, exercises, workshops and seminars 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, 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.
In the middle of the semester, normal teaching activities (lectures, exercises, workshops) may be interrupted for degree examinations, examinations reserved for out-of-course students, seminars, tutoring and remedial teaching activities.

The lesson schedule for the entire academic year is published on the Course of Study's website beforethe 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. For practical reasons, timetable compatibility is not guaranteed for all formally possible choices of optional subjects. Students must therefore formulate their study plan taking into account their timetable.

Art. 9. Examinations and other profit exams

Profit exams can be carried out in written, oral, or written and oral, according to the methods indicatedin 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 ofthe 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.

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 withart. 20 paragraph 4 of the University Degree regulation.

The examinations are conducted in English. The grade assignment, in both EMARO and JEMARO, is on a 100-scale basis (with a sufficiency of 60). For the purposes of registration in theItalian system, the grade in base 100 is transformed into grade in base 30, taking into account the *European Credit Transfer and accumulation System*[3] (ECTS) framework.

For the purposes of aligning the course with the other EMARO and JEMARO partners, students of both international programmes who fail to pass their exams - or refuse the grade - at the first examination or in any case on the date indicated among those available for such students, may attend subsequent examinations, but with a limitation of the grade to a pass mark only (60/100; 18/30).

In the case of courses structured in modules with several lecturers, the lecturers participate collectively in the overall assessment of the student's performance, which cannot, however, be divided into separate assessments of individual modules. Passing the examination for a module-based course is conditioned on passing the examinations for the individual modules.

The calendar of profit exams is established by the ministerial deadline for the following academic year and it is published on the website of the Master's Degree Course. The calendar of any intermediate verificationtests is established by the DPB and communicated to the students at the beginning of each teaching cycle.

Examinations are held in periods of interruption of classes. All profit examinations of training activities must be passed by the student by the deadline provided by the Polytechnic School's student secretariat for the final examination, as indicated in the "Graduates' memo" published on the Master's Degree course website.

[3] Website: https://ec.europa.eu/education/resources-and-tools/european-credit-transfer-and-accumulation-systemects_en.

The result of the examination, with the vote obtained, is verbalized in accordance with art. 20 of the University Degree regulation.

The committees for profit examinations are appointed by the Director of the Department or by delegation by the Coordinator of the course of study and are composed of at least 3 members. At least 2 members will be present at each examination session. The teacher responsible for the course is a member with the function of chairman. Members of the committee may be subject-matter experts identified by the study course council on the basis of criteria that ensure possession of scientific, teaching or professional requirements; these requirements may be presumed to be possessed by retired university lecturers. At least one deputy chairman must be identified for each committee. In each examination session, the committees are chaired by the president or an alternate president.

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 forin the University Degree regulation, art. 18. 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. 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 totime 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. 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.

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 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 suitabledocumentation proving the equivalence of content between the teaching unit abroad and the teachingunit that intends to replace taught in the Master's Degree Course in Robotics Engineering. Equivalenceshall 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.

In the case of periods of study abroad for the preparation of the final examination, the number of credits recognised for this activity is established in relation to the duration of the period spent abroad.

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 yearthe 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 EMARO fees provided for by the programme. 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 programme 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 thinking 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.

The Committee for the final examination is composed of at least five members, the majority of whommust 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 membersof 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 ofevaluations, 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.

Art. 13. Guidance services and tutoring
The Polytechnic School, in agreement with the DIBRIS Department, organises and manages a guidance and support service for students, in order to promote the different second-level training pathways and 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 theDPB 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. Ifthe related training activity provides for a vote, it may be varied from the one previously obtained, ona 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.

Approved by resolution of the Board of the Master's Degree Course on 6th Mai 2021.

Annex 1

DEGREE REGULATION – Special part

List of training activities and related training objectives

1° year (cohort 2022/2023)

Course Code	Course name	SSD (Disciplinary scientific area)	ECTS	Type/Area	Learning Outcomes	Propaedeutic subjects	Hours reserved to assisted teaching activities	Hours reserved to personal study
56846	MODELING AND CONTROL OF MANIPULATORS	ING-INF/04	6	CORE / Computer Engineering	This course presents the fundamentals of the modelling and control techniques of serial manipulators. Topics include robot architectures, geometric modelling, kinematic modelling, dynamic modelling and its applications, as well as the classical PID controller and computed torque controller.	-	48	102
80514	MECHANICS OF MECHANISMS AND MACHINES	ING-IND/13	5	RELATED OR SUPPLEMENTARY LEARNING ACTIVITY	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
104729	RESEARCH TRACK 1		5	OTHER ACTIVITY / Training and orientation activity	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
104730	RESEARCH TRACK 2		5	OTHER ACTIVITY / Training and orientation activity	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
30 CFU tra i seguenti insegnamenti:								
86736	ADVANCED AND ROBOT PROGRAMMING	ING-INF/05	5	CORE / Computer Engineering	The goal of the course is to give the students the fundamentals of POSIX programming, concurrent programming, and inter-process communication (i.e., interrupts, signals, pipes, threads, semaphores, shared memory, sockets, publish/subscribe methods). The objective involves both theoretical knowledge and practical work (coding for multiprocess / distributed systems).	-	40	85
104734	ARTIFICIAL INTELLIGENCE FOR ROBOTICS I	ING-INF/05	5	CORE / Computer Engineering	The goal of the course is to provide the foundations of knowledge-based intelligent autonomous agents.	-	40	85
80181	CONTROL OF LINEAR MULTI-VARIABLE SYS.	ING-INF/04	5	CORE / Computer Engineering	The obejctive of the course is that of presenting the basic methodologies for the analysis and control of linear (time-invariant) multivariable systems. The course will start with a review of the basic concepts relevant to linear stystems, in continuous and discrete time. Stability and structural properties of linear multivariable dynamic systems will be addressed. Matrix pseudo inversion methods will be discussed with reference to robot inverse kinematics and control allocation problems. The course will end with the treatment of some specific topics concerning linear multivariable control, as closed-loop pole assignment and feedback control based on state observers.	-	40	85
80158	HUMAN COMPUTER INTERACTION	ING-INF/05	5	CORE / Computer Engineering	The course faces theories and techniques for the design of interactive systems and multimodal systems.	-	40	85
106956	MOBILE ROBOTS	ING-INF/04	5	CORE / Computer Engineering	The class first develops the kinematic modelling 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
80169	REAL-TIME OPERATING SYSTEMS	ING-INF/05	5	CORE / Computer Engineering	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
86738	ROBOT DYNAMICS AND CONTROL	ING-INF/04	5	CORE / Computer Engineering	The course introduces the dynamic modelling of robot manipulators and the fundamentals of dynamic control of robots. These aspects are the key elements for the design of robot controllers and for the implementation of robot-controlled operations involving interaction of the robot with objects (e.g., for their manipulation), the environment (e.g., force control), humans (e.g. human robot collaborative tasks).	-	40	85

86805	SOFTWARE ARCHITECTURES FOR ROBOTICS	ING-INF/05	5	CORE / Computer Engineering	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

10 CFU tra i seguenti insegnamenti:

104731	ARTIFICIAL INTELLIGENCE FOR ROBOTICS II	ING-INF/05	5	ELECTIVE LEARNING ACTIVITY	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
86735	COMPUTER VISION	INF/01	5	ELECTIVE LEARNING ACTIVITY	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 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.	-	40	85
86746	ITALIAN LANGUAGE (FOR FOREIGN STUDENTS) - BRIEF	L-FIL-LET/12	4	ELECTIVE LEARNING ACTIVITY	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
52164	ITALIAN LANGUAGE (FOR FOREIGN STUDENTS) - LONG	L-FIL-LET/12	5	ELECTIVE LEARNING ACTIVITY	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
86928	MACHINE LEARNING FOR ROBOTICS I	INF/01	5	ELECTIVE LEARNING ACTIVITY	The goal of the class is to present Artificial Neural Networks and other well-known Machine Learning techniques as systems for solving supervised and 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.	-	40	85
80183	MECHANICAL DESIGN METHODS IN ROBOTICS	ING-IND/13	5	ELECTIVE LEARNING ACTIVITY	This course presents the overview of the design process-specification, conceptual design, product design. The students will learn basic principles of industrial robot design.	-	40	85
86733	OPTIMISATION TECHNIQUES	MAT/09	5	ELECTIVE LEARNING ACTIVITY	The Course presents methodological and computational aspects of a wide range of optimization methods for the solution of a variety of problems, with particular attention to models and problems arising in Robotics Engineering. It is structured according to the basic topics of problem modelling, its tractability, its solution by means of algorithms that can be implemented on computers, and related software tools.	-	40	85
105038	SIGNAL PROCESSING IN ROBOTICS	ING-IND/31	5	ELECTIVE LEARNING ACTIVITY	The goal of the course is to provide the basic notions for the design of analog (both passive and active) and digital filters. The topics are proposed to students through both theoretical lessons and practical activities such as the simulation and the hardware realization of filters.	-	40	85
80186	SYSTEM IDENTIFICATION	ING-INF/04	5	ELECTIVE LEARNING ACTIVITY	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

2° year (cohort 2022/2023)

Course Code	Course name	SSD (Disciplinary scientific area)	ECTS	Type/Area	Learning Outcomes	Propaedeutic subjects	Hours reserved to assisted teaching activities	Hours reserved to personal study
60452	MASTER THESIS		30	FINAL EXAMINATION	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 developed with a clear English language, be based on well-defined design and experimental practices, as well as on critical thinking.	-	0	750
86732	RESEARCH METHODOLOGY	ING-IND/13	1	RELATED OR SUPPLEMENTARY LEARNING ACTIVITY	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
12 CFU tra i seguenti insegnamenti:								
80188	AMBIENT INTELLIGENCE	ING-INF/05	4	CORE / Computer Engineering	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
98457	COOPERATIVE ROBOTICS	ING-INF/04	4	CORE / Computer Engineering	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
80190	EMBEDDED SYSTEMS	ING-INF/04	4	CORE / Computer Engineering	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
106723	EXPERIMENTAL ROBOTICS LABORATORY	ING-INF/05	4	CORE / Computer Engineering	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
104855	MACHINE LEARNING FOR ROBOTICS II	ING-INF/05	4			-	-	-
	86798 - MACHINE LEARNING AND DATA ANALYSIS	ING-INF/05	3	CORE / Computer Engineering	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
	104856 - ROBOTICS USE CASES	ING-INF/05	1	CORE / Computer Engineering	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
94866	SOCIAL ROBOTICS	ING-INF/05	4	CORE / Computer Engineering	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 behaviour; 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
80186	SYSTEM IDENTIFICATION	ING-INF/04	4	CORE / Computer Engineering	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.	-	32	68
108857	TRUSTWORTHY ARTIFICIAL INTELLIGENCE FOR ROBOTICS		4			-	32	68
	108606 - TRUSTWORTHY ARTIFICIAL INTELLIGENCE	ING-INF/05	3	CORE / Computer Engineering	The aim of this course is to provide students with fundamental and advanced concepts on the security of machine learning and trustworthy artificial intelligence.	-	24	51

	108858 - TRUSTWORTHY AI ROBOTICS USE CASES	ING-INF/05	1	CORE / Computer Engineering	Specific use cases on the evaluation of the security of the object recognition system of the iCub robot will be addressed. Students will also get ability to answer open-ended questions with closed books, solve numerical exercises, use open-source libraries for the security evaluation of machine learning algorithms used by modern robots.	-	8	17
104737	VIRTUAL REALITY FOR ROBOTICS	ING-INF/05	4	CORE / Computer Engineering	Starting from the knowledge on the fundamentals of graphics, modelling 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

4 CFU tra i seguenti insegnamenti:

80192	ADVANCED MODELLING AND SIMULATION TECHNIQUES FOR ROBOTS	ING-IND/13	4	RELATED OR SUPPLEMENTARY LEARNING ACTIVITY	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
66044	FLEXIBLE AUTOMATION	ING-IND/13	4	RELATED OR SUPPLEMENTARY LEARNING ACTIVITY	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. In greater detail, design and development techniques are proposed for intelligent flexible automation of industrial production systems with a view to Factory 4.0.	-	32	68
109205	SOFT ROBOTICS	ING-IND/13	4	RELATED OR SUPPLEMENTARY LEARNING ACTIVITY	The course explores how compliance in the robot body can be exploited for dealing with task and environment uncertainty and for interacting with humans. “Softness” offers higher safety, larger variability of movement and higher dexterity and shows the potential for building safer, cheaper and more intelligent autonomous robots than conventional robotics can achieve. Taking inspiration from biological systems, which are able to survive in complex and unstructured environments thanks to the intrinsic compliance of their soft and flexible body, the focus is in understanding the mechanisms at the base of their high adaptability and in replicating them in robots for achieving intelligent behaviour. In particular the role of body morphology (i.e., form and structure), how biological systems use their body to control basic actions, and how intelligent behaviour emerges from the interaction between the body and the environment in which it is placed, constitute the foundation of the design of new soft actuators and sensors and new control strategies for the robot of the future.	-	32	68

12 CFU tra i seguenti insegnamenti:

80188	AMBIENT INTELLIGENCE	ING-INF/05	4	RELATED OR SUPPLEMENTARY LEARNING ACTIVITY	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
98454	BIOMEDICAL ROBOTICS	ING-INF/06	4	RELATED OR SUPPLEMENTARY LEARNING ACTIVITY	The purpose of this course is to provide a perspective on robotic technologies applied to (and inspired by) themes of biomedical research and practice. The first part of the course is intended to offer a background on biological signals and their applications in human-machine interfaces. The second part is devoted to in-depth analysis of specific applications. These include basic research in sensory-motor systems, advanced surgical and diagnostic techniques, body and brain machine interfaces, robots for assistance and rehabilitation, prosthetics, biomimetic robotics	-	32	68
98457	COOPERATIVE ROBOTICS	ING-INF/04	4	RELATED OR SUPPLEMENTARY LEARNING ACTIVITY	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
108964	DESIGN OF AUTOMATIC MACHINERY AND ROBOTS	ING-IND/15	4	RELATED OR SUPPLEMENTARY LEARNING ACTIVITY	To provide, by means of theoretical concepts and project-based learning, the knowledge of those engineering methods required to develop a project of industrial automation: from functionality identification to the integrated design of mechanical structure and actuation subsystem. The course is composed of lectures and lab exercises (by means of a dedicated CAD/CAE software tool)	-	32	68
80190	EMBEDDED SYSTEMS	ING-INF/04	4	RELATED OR SUPPLEMENTARY LEARNING ACTIVITY	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
106723	EXPERIMENTAL ROBOTICS LABORATORY	ING-INF/05	4	RELATED OR SUPPLEMENTARY LEARNING ACTIVITY	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

108861	INTRODUCTION TO QUANTUM INFORMATION AND COMPUTATION FOR ROBOTICS	FIS/02	4	RELATED OR SUPPLEMENTARY LEARNING ACTIVITY	This course aims to introduce the key concepts and methods of Quantum Information and Computation. The first part will provide the operational elements of quantum mechanics and quantum information: superposition principle, quantum entanglement, the quantum bit (qubit) and quantum logical gates. The second part will introduce the basic quantum algorithms and applications to informatics such as quantum database search algorithm, quantum teleportation and superdense coding. The final part will deal with some possible applications to robotics. It will be shown as the above ideas and concepts can be introduced in software architecture for robots that exploit quantum-inspired perception, reasoning and action techniques.	-	32	68
86746	ITALIAN LANGUAGE (FOR FOREIGN STUDENTS) - BRIEF	L-FIL-LET/12	4	RELATED OR SUPPLEMENTARY LEARNING ACTIVITY	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
52164	ITALIAN LANGUAGE (FOR FOREIGN STUDENTS) - LONG	L-FIL-LET/12	5	RELATED OR SUPPLEMENTARY LEARNING ACTIVITY	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
108856	LINGUISTICS AND PHYLOSOPHY OF LANGUAGE	M-PSI/01	4	RELATED OR SUPPLEMENTARY LEARNING ACTIVITY	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
104855	MACHINE LEARNING FOR ROBOTICS II	ING-INF/05	4			-	-	-
	86798 - MACHINE LEARNING AND DATA ANALYSIS	ING-INF/05	3	RELATED OR SUPPLEMENTARY LEARNING ACTIVITY	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
	104856 - ROBOTICS USE CASES	ING-INF/05	1	RELATED OR SUPPLEMENTARY LEARNING ACTIVITY	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
104749	PSYCHOLOGY OF PERCEPTION AND ACTION	M-PSI/01	4	RELATED OR SUPPLEMENTARY LEARNING ACTIVITY	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
94866	SOCIAL ROBOTICS	ING-INF/05	4	RELATED OR SUPPLEMENTARY LEARNING ACTIVITY	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 behaviour; 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
80186	SYSTEM IDENTIFICATION	ING-INF/04	4	RELATED OR SUPPLEMENTARY LEARNING ACTIVITY	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.	-	32	68
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	108858 - TRUSTWORTHY AI ROBOTICS USE CASES	ING-INF/05	1	RELATED OR SUPPLEMENTARY LEARNING ACTIVITY	Specific use cases on the evaluation of the security of the object recognition system of the iCub robot will be addressed. Students will also get ability to answer open-ended questions with closed books, solve numerical exercises, use open-source libraries for the security evaluation of machine learning algorithms used by modern robots.	-	8	17
104737	VIRTUAL REALITY FOR ROBOTICS	ING-INF/05	4	RELATED OR SUPPLEMENTARY LEARNING ACTIVITY	Starting from the knowledge on the fundamentals of graphics, modelling 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

SCUOLA POLITECNICA
Corso di Laurea Magistrale in *Robotics Engineering* Classe LM-32
REGOLAMENTO DIDATTICO – Parte Generale

INDICE

Art. 1. Premessa e ambito di competenza

Il presente Regolamento, in conformità allo Statuto e al Regolamento Didattico di Ateneo (parte generale e parte speciale), disciplina gli aspetti organizzativi dell'attività didattica del Corso di Laurea Magistrale in *Robotics Engineering*, nonché ogni diversa materia ad esso devoluta da altre fonti legislative e regolamentari.

Il Regolamento Didattico del Corso di Laurea Magistrale in *Robotics Engineering* è deliberato, ai sensi dell'articolo 25, commi 1 e 4 del Regolamento Didattico di Ateneo, parte generale, dal Consiglio del Corso di Studio (CCS) di *Robotics Engineering* a maggioranza dei componenti e sottoposto all'approvazione del Consiglio del Dipartimento di riferimento (e dei consigli degli eventuali Dipartimenti associati), sentita la Scuola Politecnica, previo parere favorevole della Commissione Paritetica di Scuola e di Dipartimento, ove esistente.

Le delibere del CCS possono essere assunte anche in modalità telematica ai sensi dei sovraordinati regolamenti e, in particolare, dell'articolo 14 "Riunioni con modalità telematiche" del vigente Regolamento Generale di Ateneo (in vigore dal 19/12/2018).

Art. 2. Requisiti di ammissione e modalità di verifica della preparazione individuale

L'ammissione al Corso di Laurea Magistrale in *Robotics Engineering* è subordinata al possesso di specifici requisiti curricolari e di adeguatezza della preparazione personale.

I requisiti curricolari per poter accedere al Corso di Laurea Magistrale in *Robotics Engineering* sono soddisfatti se lo studente è in possesso di una Laurea o Laurea Magistrale ex D.M. 270/2004 conseguita presso una Università italiana, o Laurea equiparata ex Decreto Interministeriale del 9 Luglio 2009), nelle seguenti classi:

- Classe delle Lauree in Ingegneria dell'Informazione,
- Classe delle Lauree in Scienze e Tecnologie Informatiche,
- Classe di Lauree in Ingegneria Industriale,

oppure titoli di studio analoghi di livello *Bachelor of Science* (B.Sc.) o *Master of Science* (M.Sc.) riconosciuti da

Università straniere. L'equivalenza del titolo di studio straniero è determinata attraverso l'analisi del titolo accademico, del CV del candidato e del Transcript of Records.
Inoltre, è verificata l'adeguatezza della personale preparazione, in particolare nei seguenti campi:

- analisi matematica, geometria, fisica, fisica matematica,
- fondamenti di elettronica,
- fondamenti di informatica,
- fondamenti di automatica,
- fondamenti di meccanica,
- fondamenti di telecomunicazioni,
- fondamenti di tecnologie di sensori e attuatori.

Nel caso di possesso di Lauree differenti da quelle indicate sopra, il CCS verifica la presenza dei requisiti curricolari o delle conoscenze equivalenti, sulla base degli esami sostenuti dallo studente nel Corso di Laurea di provenienza, nonché la presenza di eventuali esami extra-curricolari, le attività di *stage* e le esperienze lavorative maturate.

È inoltre richiesta un'adeguata conoscenza della lingua inglese non inferiore al livello B2 o equivalente, verificata tramite certificazione, conseguita da non più di 3 anni o, in assenza di essa, tramite superamento del test B2 erogato dal Settore Sviluppo Competenze linguistiche (di Ateneo). Il requisito della conoscenza linguistica è soddisfatto anche in possesso di una laurea in lingua inglese, da certificare tramite documento ufficiale o lettera dell'Università che ha erogato il titolo triennale, da cui si evinca che gli studi si sono svolti in lingua inglese.
Oltre a ciò, gli studenti che al momento dell'accesso al corso di Laurea Magistrale non posseggono una sufficiente conoscenza della lingua italiana scritta e orale, dovranno obbligatoriamente prevedere nel proprio percorso formativo l'inserimento di almeno uno dei due insegnamenti di italiano come lingua straniera, previsti nell'Offerta Formativa del corso di Laurea.

La verifica del possesso dei requisiti curriculari e individuali da parte dei candidati è accertata dal Coordinatore o da una apposita Commissione, che opera secondo un protocollo ispirato e analogo a quello di selezione utilizzato per l'ammissione previsto all'interno dei progetti Europei Erasmus+ *European Master on Advanced Robotics* (EMARO) e Japan-Europe *Master on Advanced Robotics*[4] (JEMARO), di cui l'Università degli Studi di Genova è partener. Per ciascun candidato la commissione valuterà:

1. il "potenziale accademico" (ad esempio, media dei voti, *class rank*, GPA),
2. la rilevanza del titolo di studio di I livello,
3. la qualità dell'Università che ha erogato il titolo di I livello,
4. la conoscenza della lingua inglese, comunque di livello non inferiore ad un B2 o scala equivalente,
5. le lettere di motivazione,
6. le lettere di referenza (non obbligatorie,
7. altri aspetti del curriculum vitae (ad esempio, altri titoli di studio, esperienze lavorative, qualificazioni professionali).

Nell'Avviso per Ammissione ai Corsi di Laurea Magistrale della Scuola Politecnica e sul sito web del Corso di Laurea Magistrale[5] sono indicati: la composizione della Commissione per l'ammissione, la documentazione richiesta e le modalità di presentazione della stessa, i criteri di valutazione dei candidati, gli esiti delle verifiche.

[4] Sito web: https://master-jemaro.ec-nantes.fr/.
[5] https://courses.unige.it/10635

La data di scadenza per l'iscrizione è il 10 gennaio del primo A. A. di corso.

Per i candidati provenienti da Paesi Extra EU, con residenza estera e in possesso di titolo di studio estero, la procedura di presentazione della propria candidatura ai fini della verifica dell'ammissibilità viene gestita tramite apposito portale online, pubblicizzato annualmente sui siti web istituzionali e sul sito web del Corso di Studio, secondo un calendario e con scadenze stabilite annualmente e comunicate debitamente agli studenti, secondo un calendario e con scadenze stabilite annualmente e comunicate debitamente agli studenti.
A seguito del caricamento della documentazione richiesta sul portale, verranno effettuate le seguenti verifiche:

- completezza dei documenti
- verifica dei requisiti curriculari
- verifica della conoscenza della lingua inglese

I candidati che superano queste verifiche passano a una doppia fase di valutazione:

- valutazione dei titoli
- valutazione del candidato

A valle di queste valutazioni, l'esito della procedura di ammissione prevede l'esito "ammesso" o "ammesso condizionatamente al conseguimento della laurea".

Art. 3. Attività formative
L'elenco degli insegnamenti e delle altre attività formative attivabili nella coorte 2022-2024 è riportato nell'apposito allegato (Allegato 1), che costituisce parte integrante del presente regolamento.

Per ogni insegnamento è individuato un docente responsabile. È docente responsabile di un insegnamento chi ne sia titolare a norma di legge, ovvero colui al quale il Consiglio di Dipartimento di afferenza abbia attribuito la responsabilità stessa in sede di affidamento dei compiti didattici ai docenti.

La lingua usata per erogare le attività formative (lezioni, esercitazioni, laboratori) è l'inglese.

Art. 4. Iscrizione a singole attività formative
In conformità con l'articolo 5 del Regolamento di Ateneo per gli studenti, per iscriversi a singole attività formative occorre possedere un titolo di studio che permetta l'accesso all'Università.

Art. 5. Curricula
Il Corso di Laurea Magistrale non è articolato in curricula.

Art. 6. Impegno orario complessivo
La definizione della frazione oraria dedicata a lezioni o attività didattiche equivalenti è stabilita, per ogni insegnamento, dal CCS contestualmente alla definizione del Manifesto degli Studi. In ogni caso, si assume un intervallo di variabilità della corrispondenza tra ore aula e crediti formativi (CFU) pari a 8÷10, intendendo per "ore aula" le ore di lezione o di attività didattica assistita.

La definizione dell'impegno orario complessivo presunto, riservato allo studio personale o ad altre attività formative di tipo individuale, è stabilito, per ogni insegnamento, nell'Allegato 1 del presente Regolamento.

Il Direttore del Dipartimento di Informatica, Bioingegneria, Robotica e Ingegneria dei Sistemi (DIBRIS) e il Coordinatore

del CCS sono incaricati di verificare il rispetto delle predette prescrizioni.

Art. 7. Piani di studio e propedeuticità
Gli studenti devono iscriversi a tempo pieno.

Ogni studente svolge la propria attività formativa tenendo conto del piano di studio predisposto dal Corso di Laurea Magistrale in *Robotics Engineering*, distinto per anni di corso e pubblicato nel Manifesto degli Studi. Il piano di studio formulato dallo studente deve contenere l'indicazione delle attività formative, con i relativi crediti che intende conseguire, previsti dal piano di studio ufficiale per tale periodo didattico, da un minimo di 45 ad un massimo di 65 dei CFU previsti in ogni anno. Il percorso formativo dello studente può essere vincolato attraverso un sistema di propedeuticità, indicate per ciascun insegnamento nel Manifesto degli Studi.

La modalità e il termine per la presentazione del piano di studio sono stabiliti annualmente dalla Scuola Politecnica e riportate nel Manifesto degli Studi. Inoltre, potranno essere riportate sul sito del Corso di Laurea Magistrale oppure comunicate direttamente agli studenti norme e indicazioni specifiche, anche relative alle successive richieste di modifica del piano di studio.

Lo studente può aggiungere al proprio piano di studio insegnamenti "fuori piano" fino ad un massimo di 12 CFU. Tali insegnamenti non sono presi in considerazione ai fini del conseguimento della laurea e non concorrono al calcolo della media dei voti.

Gli studenti iscritti al Corso di Laurea Magistrale in Robotics Engineering che fanno parte di uno dei percorsi internazionali, EMARO o JEMARO, sono soggetti ad alcuni vincoli aggiuntivi riguardo alla compilazione del proprio piano di studi. Tali limitazioni potranno essere riportate sul sito del Corso di Laurea Magistrale.

Art. 8. Frequenza e modalità di svolgimento delle attività didattiche
Gli insegnamenti possono assumere la forma di:

- lezioni, tenute anche a distanza mediante mezzi telematici
- esercitazioni pratiche
- esercitazioni in laboratorio
- seminari tematici

La frequenza alle lezioni e alle altre forme di attività formativa è obbligatoria. Gli studenti sono tenuti a frequentare lezioni, esercitazioni, laboratori e seminari, secondo modalità indicate nel Manifesto degli Studi. Il CCS può esonerare lo studente dall'obbligo di frequenza, in tutto o in parte, in presenza di documentate motivazioni.

Il calendario delle lezioni è articolato in semestri. Di norma, il semestre è suddiviso in almeno 12 settimane di lezione più almeno 4 settimane complessive per prove di verifica ed esami di profitto. Il periodo destinato agli esami di profitto termina con l'inizio delle lezioni del semestre successivo.
A metà semestre, la normale attività didattica (lezioni, esercitazioni, laboratori) può essere interrotta per lo svolgimento di esami di laurea, prove riservate a studenti fuori corso, seminari, attività di tutorato e attività didattica di recupero.

L'orario delle lezioni per l'intero Anno Accademico è pubblicato sul sito web di Ateneo prima dell'inizio delle lezioni dell'Anno Accademico.

L'orario delle lezioni garantisce la possibilità di frequenza per anni di corso previsti dal vigente Manifesto degli Studi. Per

ragioni pratiche non è garantita la compatibilità dell'orario per tutte le scelte formalmente possibili degli insegnamenti opzionali. Gli studenti devono quindi formulare il proprio piano di studio tenendo conto anche dell'orario delle lezioni.

Art. 9. Esami e altre verifiche del profitto

Gli esami di profitto possono essere svolti in forma scritta, orale, o scritta e orale, secondo le modalità indicate nelle schede di ciascun insegnamento pubblicato sul sito web di Ateneo. Di norma, ogni insegnamento prevede accertamenti della preparazione durante il semestre delle lezioni (definito di seguito *continuous assessment*), il cui esito concorre alla formazione del voto dell'esame finale di profitto. Per ogni insegnamento, la quota della votazione finale riservata al *continuous assessment* è dichiarata nelle schede degli insegnamenti pubblicate sul sito web di Ateneo.

A richiesta, possono essere previste specifiche modalità di verifica dell'apprendimento che tengano conto delle esigenze di studenti disabili e di studenti con disturbi specifici dell'apprendimento (D.S.A.), in conformità all'art. 20 comma 4 del Regolamento Didattico di Ateneo.

Gli esami vengono svolti in lingua inglese. L'attribuzione del voto, in tutte le sedi dei consorzi EMARO e JEMARO, è in base 100 (con sufficienza pari a 60). Ai fini della registrazione nel sistema italiano, il voto in base 100 viene trasformato in voto in base 30, tenendo conto del *framework European Credit Transfer and accumulation System*[6] (ECTS).

Ai fini dell'allineamento del Corso di Studio alle altre sedi dei consorzi EMARO e JEMARO, gli studenti dei due programmi internazionali che non superano gli esami di profitto – o rifiutano il voto – al primo appello o comunque alla data indicata fra quelle disponibili per tali studenti, possono accedere agli appelli successivi, ma con una limitazione del voto alla sola sufficienza (60/100; 18/30).

Nel caso di insegnamenti strutturati in moduli con più docenti, questi partecipano collegialmente alla valutazione complessiva del profitto dello studente che non può, comunque, essere frazionata in valutazioni separate sui singoli moduli. Il superamento dell'esame di un insegnamento strutturato in moduli è condizionato al superamento degli esami dei singoli moduli.

Il calendario degli esami di profitto è stabilito entro la scadenza ministeriale per l'Anno Accademico successivo, e viene pubblicato sul sito web di Ateneo. Il calendario delle eventuali prove di verifica in itinere è stabilito dal CCS e comunicato agli studenti all'inizio di ogni ciclo didattico.

Gli esami si svolgono nei periodi di interruzione delle lezioni.

Tutte le verifiche del profitto relative alle attività formative debbono essere superate dallo studente entro la scadenza prevista dalla segreteria studenti della Scuola Politecnica in vista della prova finale, come indicato nel "promemoria" pubblicato sul sito del Corso di Laurea Magistrale. L'esito dell'esame, con la votazione conseguita, è verbalizzato secondo quanto previsto all'art. 20 del Regolamento Didattico di Ateneo.

Le commissioni di esame di profitto sono nominate dal Direttore del Dipartimento o su sua delega dal Coordinatore del corso di studio e sono composte da almeno 3 membri. Ad ogni sessione di esame saranno presenti almeno 2 membri. Il docente responsabile dell'insegnamento è membro con funzione di presidente. Possono essere membri della commissione cultori della materia individuati dal consiglio del corso di studio sulla base di criteri che assicurino il possesso di requisiti scientifici, didattici o professionali; tali requisiti si possono presumere posseduti da parte di docenti universitari a riposo. Per ogni commissione all'atto di nomina va individuato almeno un presidente supplente. In ogni sessione di esame le commissioni sono presiedute dal presidente o da un presidente supplente.

Art. 10. Riconoscimento di crediti

[6] Sito web: https://ec.europa.eu/education/resources-and-tools/european-credit-transfer-and-accumulation-system-ects_en.

Il Consiglio del Corso di Studio delibera sull'approvazione delle domande di passaggio o trasferimento da un altro Corso di Studi dell'Ateneo o di altre Università secondo le norme previste dal Regolamento Didattico di Ateneo, art. 18. Il CCS delibera altresì il riconoscimento, quale credito formativo, per un numero massimo di 12 CFU, di conoscenze e abilità professionali certificate ai sensi della normativa vigente. Nella valutazione delle domande di passaggio si terrà conto delle specificità didattiche e dell'attualità dei contenuti formativi dei singoli esami sostenuti, riservandosi di stabilire di volta in volta eventuali forme di verifica ed esami integrativi.
Nel quadro della normativa nazionale e regionale su alternanza formazione/lavoro, è possibile per il corso di studio prevedere, per studenti selezionati, percorsi di apprendimento che tengano conto anche di esperienze lavorative svolte presso aziende convenzionate.

Art. 11. Mobilità, studi compiuti all'estero, scambi internazionali
Il CCS supporta fortemente la mobilità studentesca, in particolare mediante la partecipazione a programmi di mobilità e scambi internazionali. A tal fine garantisce, secondo le modalità previste dalle norme vigenti, il riconoscimento dei crediti formativi conseguiti all'interno di tali programmi, e organizza le attività didattiche opportunamente.

I periodi di studi svolti all'estero sono inoltre valorizzati mediante una particolare valutazione di cui si tiene conto nella determinazione del voto di laurea, come descritto nel successivo Articolo 12.

Il CCS riconosce agli studenti iscritti, che abbiano regolarmente svolto e completato un periodo di studi all'estero, gli esami sostenuti fuori sede e il conseguimento dei relativi crediti che lo studente intenda sostituire a esami del proprio piano di studi. Ai fini del riconoscimento di tali esami, lo studente all'atto della compilazione del piano delle attività formative che intende seguire nell'Ateneo estero, dovrà produrre idonea documentazione comprovante l'equivalenza dei contenuti tra l'insegnamento impartito all'estero e l'insegnamento che intende sostituire, impartito nel Corso di Laurea Magistrale in *Robotics Engineering*. L'equivalenza è valutata dal CCS. La conversione dei voti avverrà secondo criteri approvati dal CCS, congruenti con il sistema di votazione EMARO e JEMARO (su base 100) o con il sistema Europeo ECTS.

Per i periodi di studio all'estero dedicati alla preparazione della prova finale, il numero di crediti riconosciuto relativo a tale attività è stabilito in relazione alla durata del periodo svolto all'estero.

Gli studenti iscritti al Corso di Laurea Magistrale in *Robotics Engineering* particolarmente meritevoli che superino tutti gli esami del primo anno in tempi e modi congruenti a quelli stabiliti dal consorzio EMARO possono proporsi per l'iscrizione al percorso formativo a doppio titolo EMARO. La decisione sulla loro ammissione spetta al *board internazionale* EMARO, che stabilisce ogni anno il numero di posizioni disponibili e l'ammissione sulla base della graduatoria, calcolata in base ai voti ottenuti negli esami del primo anno. Tale ammissione comporta l'obbligo di frequentare l'intero secondo anno in una delle correnti sedi estere del consorzio EMARO, con il pagamento delle tasse EMARO previste dal programma. Gli studenti EMARO sono da considerarsi iscritti al Corso di Laurea Magistrale in *Robotics Engineering* per tutto il tempo dei loro studi, anche durante la loro permanenza presso la sede estera dove svolgono il secondo anno.

La mobilità degli studenti del programma internazionale JEMARO è obbligatoria ed è limitata alla *Keio University*, partner del consorzio JEMARO. Gli studenti JEMARO sono da considerarsi iscritti al Corso di Laurea Magistrale in *Robotics Engineering* per tutto il tempo dei loro studi, anche durante la loro permanenza presso la Keio University.

Art. 12. Modalità della prova finale
La prova finale consiste nella discussione di un elaborato scritto, tendente ad accertare la preparazione tecnico-scientifica e professionale del candidato. Ai fini del conseguimento della Laurea Magistrale in *Robotics Engineering*, l'elaborato finale consiste nella redazione di una tesi di carattere teorico, sperimentale o applicativo elaborata dallo studente in modo

originale sotto la guida di uno o più relatori, su argomenti definiti attinenti a una disciplina di cui il candidato abbia superato l'esame. La tesi deve essere comunque coerente con gli argomenti sviluppati nel corso della Laurea Magistrale in *Robotics Engineering*. La tesi dovrà rivelare le capacità dello studente nell'affrontare tematiche di tipo applicativo e/o di ricerca. La tesi dovrà essere costituita da un progetto e/o dallo sviluppo di un'applicazione che proponga soluzioni innovative rispetto allo stato dell'arte. La tesi dovrà altresì rivelare:

- un'adeguata preparazione nelle discipline caratterizzanti la Laurea Magistrale in *Robotics Engineering*,
- un corretto uso delle fonti e della bibliografia,
- capacità sistematiche e argomentative,
- chiarezza nell'esposizione,
- capacità progettuale e sperimentale,
- capacità critica.

La tesi deve essere redatta in lingua inglese. In caso di utilizzo di altra lingua della Unione Europea è necessaria l'autorizzazione del CCS, la traduzione del titolo e la stesura di un ampio sommario in inglese. Tra i relatori deve essere presente almeno un docente del Corso di Studio.

La Commissione di Laurea è composta da almeno cinque componenti, la maggioranza dei quali deve essere costituita da professori di ruolo e ricercatori, ed è nominata dal Direttore del Dipartimento di Informatica, Bioingegneria, Robotica e Ingegneria dei Sistemi, o su sua delega, dal Coordinatore del Corso di Studio.

Le modalità di svolgimento della prova finale consistono nella presentazione orale della tesi di Laurea da parte dello studente alla Commissione per la prova finale, seguita da una discussione sulle questioni eventualmente poste dai componenti la Commissione. Al termine della presentazione e della discussione la Commissione assegna un voto alla tesi, il quale contribuisce alla determinazione del voto di Laurea.

La determinazione del voto di laurea da parte della Commissione avviene applicando una variazione alla media ponderata dei voti riportati nelle prove di verifica relative ad attività formative che prevedono una votazione finale, assumendo come peso il numero di crediti associati alla singola attività formativa. A seguito di una serie di valutazioni la Commissione assegna al candidato un punteggio per la prova finale.

Il voto di tesi sarà assegnato tenendo conto della valutazione della tesi e della sua discussione da parte del candidato, del fatto che il candidato si laurei in tempi brevi, e del fatto che il candidato abbia o meno acquisito crediti all'estero. In particolare:

1. la Commissione assegna un voto di tesi A in base 100 come valutazione della tesi e della sua discussione, e lo riporta successivamente ad un valore A' nell'intervallo numerico reale da 0 a N;
2. la Commissione aggiunge al voto di tesi A' espresso in base N un bonus numerico B inversamente proporzionale al tempo trascorso dalla prima data utile in cui il candidato avrebbe potuto laurearsi, fino alla seduta di Laurea del dicembre del secondo A.A. in corso;
3. la Commissione aggiunge inoltre al voto di tesi cumulativo A'+B un bonus numerico C che pesa positivamente il fatto che lo studente abbia trascorso periodi per studio e/o tesi all'estero.

La somma di A, B e C costituisce il voto di tesi complessivo. Il voto di laurea è calcolato aggiungendo il voto di tesi alla media ponderata dei voti degli esami in base 110.

Il bonus numerico B consente di valorizzare la capacità di uno studente di laurearsi in tempi brevi, mentre il bonus numerico C consente di valorizzare i periodi di studi svolti all'estero.

Art. 13. Orientamento e tutorato

La Scuola Politecnica, di concerto con il Dipartimento di Informatica, Bioingegneria, Robotica e Ingegneria dei Sistemi, organizza e gestisce un servizio di orientamento e di sostegno degli studenti, al fine di promuovere i diversi percorsi formativi di secondo livello e incentivare una proficua partecipazione attiva alla vita universitaria in tutte le sue forme.

Il CCS individua al suo interno un numero di tutor in proporzione al numero degli studenti iscritti. I nominativi dei tutor sono reperibili nel sito web del corso di Laurea Magistrale.

Art. 14. Verifica dell'obsolescenza dei crediti

I crediti acquisiti nell'ambito del Corso di Laurea Magistrale in *Robotics Engineering* hanno validità per 6 anni. Trascorso il periodo indicato, i crediti acquisiti debbono essere convalidati con apposita delibera qualora il CCS riconosca la non obsolescenza dei relativi contenuti formativi. Qualora il CCS riconosca l'obsolescenza anche di una sola parte dei relativi contenuti formativi, lo stesso CCS stabilisce le prove integrative che dovranno essere sostenute dallo studente, definendo gli argomenti delle stesse e le modalità di verifica. Una volta superate le verifiche previste, il CCS convalida i crediti acquisiti con apposita delibera. Qualora la relativa attività formativa preveda una votazione, la stessa potrà essere variata rispetto a quella precedentemente ottenuta, su proposta della Commissione d'esame che ha proceduto alla verifica.

Art. 15. Manifesto degli studi

Il Dipartimento di Informatica, Bioingegneria, Robotica e Ingegneria dei Sistemi, sentita la Scuola Politecnica, pubblica annualmente il Manifesto degli Studi sul sito web del Corso di Laurea Magistrale. Nel Manifesto sono indicate le principali disposizioni dell'Ordinamento Didattico e del Regolamento Didattico del Corso di Laurea Magistrale, a cui eventualmente si aggiungono indicazioni integrative. Il Manifesto degli studi del Corso di Laurea Magistrale contiene l'elenco degli insegnamenti attivati per l'Anno Accademico in questione. Le schede dei singoli insegnamenti sono pubblicate sul sito web di Ateneo.

Il presente Regolamento Didattico è stato approvato con Delibera del Consiglio del Corso di Laurea Magistrale in Robotics Engineering del 6 maggio 2022

REGOLAMENTO DIDATTICO – Parte Speciale

1° anno (coorte 2022/2023)

Codice	Disciplina	Settore	CFU	Tipologia/Ambito	Obiettivi Formativi	Propedeuticità	Ore riservate attività didattica assistita	Ore riservate allo studio personale
56846	MODELING AND CONTROL OF MANIPULATORS	ING-INF/04	6	6 CFU CARATTERIZZANTI Ingegneria Informatica	This course presents the fundamentals of the modelling and control techniques of serial manipulators. Topics include robot architectures, geometric modelling, kinematic modelling, dynamic modelling and its applications, as well as the classical PID controller and computed torque controller.	-	48	102
80514	MECHANICS OF MECHANISMS AND MACHINES	ING-IND/13	5	5 CFU AFFINI O INTEGRATIVE Attività Formative Affini o Integrative	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
104729	RESEARCH TRACK 1		5	5 CFU ALTRE ATTIVITA' Tirocini Formativi e di Orientamento	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
104730	RESEARCH TRACK 2		5	5 CFU ALTRE ATTIVITA' Tirocini Formativi e di Orientamento	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
30 CFU tra i seguenti insegnamenti:								
86736	ADVANCED AND ROBOT PROGRAMMING	ING-INF/05	5	5 CFU CARATTERIZZANTI Ingegneria Informatica	The goal of the course is to give the students the fundamentals of POSIX programming, concurrent programming, and inter-process communication (i.e., interrupts, signals, pipes, threads, semaphores, shared memory, sockets, publish/subscribe methods). The objective involves both theoretical knowledge and practical work (coding for multiprocess / distributed systems).	-	40	85
104734	ARTIFICIAL INTELLIGENCE FOR ROBOTICS I	ING-INF/05	5	5 CFU CARATTERIZZANTI Ingegneria Informatica	The goal of the course is to provide the foundations of knowledge-based intelligent autonomous agents.	-	40	85
80181	CONTROL OF LINEAR MULTI-VARIABLE SYS.	ING-INF/04	5	5 CFU CARATTERIZZANTI Ingegneria Informatica	The obejctive of the course is that of presenting the basic methodologies for the analysis and control of linear (time-invariant) multivariable systems. The course will start with a review of the basic concepts relevant to linear stystems, in continuous and discrete time. Stability and structural properties of linear multivariable dynamic systems will be addressed. Matrix pseudo inversion methods will be discussed with reference to robot inverse kinematics and control allocation problems. The course will end with the treatment of some specific topics concerning linear multivariable control, as closed-loop pole assignment and feedback control based on state observers.	-	40	85
80158	HUMAN COMPUTER INTERACTION	ING-INF/05	5	5 CFU CARATTERIZZANTI Ingegneria Informatica	The course faces theories and techniques for the design of interactive systems and multimodal systems.	-	40	85
106956	MOBILE ROBOTS	ING-INF/04	5	5 CFU CARATTERIZZANTI Ingegneria Informatica	The class first develops the kinematic modelling 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
80169	REAL-TIME OPERATING SYSTEMS	ING-INF/05	5	5 CFU CARATTERIZZANTI Ingegneria Informatica	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
86738	ROBOT DYNAMICS AND CONTROL	ING-INF/04	5	5 CFU CARATTERIZZANTI Ingegneria Informatica	The course introduces the dynamic modelling of robot manipulators and the fundamentals of dynamic control of robots. These aspects are the key elements for the design of robot controllers and for the implementation of robot-controlled operations involving interaction of the robot with objects (e.g., for their manipulation), the environment (e.g., force control), humans (e.g. human robot collaborative tasks).	-	40	85
86805	SOFTWARE ARCHITECTURES FOR ROBOTICS	ING-INF/05	5	5 CFU CARATTERIZZANTI Ingegneria Informatica	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

10 CFU tra i seguenti insegnamenti:

104731	ARTIFICIAL INTELLIGENCE FOR ROBOTICS II	ING-INF/05	5	5 CFU A SCELTA A Scelta dello Studente	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
86735	COMPUTER VISION	INF/01	5	5 CFU A SCELTA A Scelta dello Studente	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 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.	-	40	85
86746	ITALIAN LANGUAGE (FOR FOREIGN STUDENTS) - BRIEF	L-FIL-LET/12	4	4 CFU A SCELTA A Scelta dello Studente	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
52164	ITALIAN LANGUAGE (FOR FOREIGN STUDENTS) - LONG	L-FIL-LET/12	5	5 CFU A SCELTA A Scelta dello Studente	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
86928	MACHINE LEARNING FOR ROBOTICS I	INF/01	5	5 CFU A SCELTA A Scelta dello Studente	The goal of the class is to present Artificial Neural Networks and other well-known Machine Learning techniques as systems for solving supervised and 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.	-	40	85
80183	MECHANICAL DESIGN METHODS IN ROBOTICS	ING-IND/13	5	5 CFU A SCELTA A Scelta dello Studente	This course presents the overview of the design process-specification, conceptual design, product design. The students will learn basic principles of industrial robot design.	-	40	85
86733	OPTIMISATION TECHNIQUES	MAT/09	5	5 CFU A SCELTA A Scelta dello Studente	The Course presents methodological and computational aspects of a wide range of optimization methods for the solution of a variety of problems, with particular attention to models and problems arising in Robotics Engineering. It is structured according to the basic topics of problem modelling, its tractability, its solution by means of algorithms that can be implemented on computers, and related software tools.	-	40	85
105038	SIGNAL PROCESSING IN ROBOTICS	ING-IND/31	5	5 CFU A SCELTA A Scelta dello Studente	The goal of the course is to provide the basic notions for the design of analog (both passive and active) and digital filters. The topics are proposed to students through both theoretical lessons and practical activities such as the simulation and the hardware realization of filters.	-	40	85
80186	SYSTEM IDENTIFICATION	ING-INF/04	5	5 CFU A SCELTA A Scelta dello Studente	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

2° anno (coorte 2022/2023)

Codice	Disciplina	Settore	CFU	Tipologia/Ambito	Obiettivi Formativi	Propedeuticità	Ore riservate attività didattica assistita	Ore riservate allo studio personale
60452	MASTER THESIS		30	30 CFU PROVA FINALE Per la Prova Finale	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 developed with a clear English language, be based on well-defined design and experimental practices, as well as on critical thinking.	-	0	750
86732	RESEARCH METHODOLOGY	ING-IND/13	1	1 CFU AFFINI O INTEGRATIVE Attività Formative Affini o Integrative	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
12 CFU tra i seguenti insegnamenti:								
80188	AMBIENT INTELLIGENCE	ING-INF/05	4	4 CFU CARATTERIZZANTI Ingegneria Informatica	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
98457	COOPERATIVE ROBOTICS	ING-INF/04	4	4 CFU CARATTERIZZANTI Ingegneria Informatica	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
80190	EMBEDDED SYSTEMS	ING-INF/04	4	4 CFU CARATTERIZZANTI Ingegneria Informatica	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
106723	EXPERIMENTAL ROBOTICS LABORATORY	ING-INF/05	4	4 CFU CARATTERIZZANTI Ingegneria Informatica	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
104855	MACHINE LEARNING FOR ROBOTICS II	ING-INF/05	4			-	-	-
	86798 - MACHINE LEARNING AND DATA ANALYSIS	ING-INF/05	3	3 CFU CARATTERIZZANTI Ingegneria Informatica	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
	104856 - ROBOTICS USE CASES	ING-INF/05	1	1 CFU CARATTERIZZANTI Ingegneria Informatica	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
94866	SOCIAL ROBOTICS	ING-INF/05	4	4 CFU CARATTERIZZANTI Ingegneria Informatica	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 behaviour; 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
80186	SYSTEM IDENTIFICATION	ING-INF/04	4	4 CFU CARATTERIZZANTI Ingegneria Informatica	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.	-	32	68
108857	TRUSTWORTHY ARTIFICIAL INTELLIGENCE FOR ROBOTICS		4			-	-	-
	108606 - TRUSTWORTHY ARTIFICIAL INTELLIGENCE	ING-INF/05	3	3 CFU CARATTERIZZANTI Ingegneria Informatica	The aim of this course is to provide students with fundamental and advanced concepts on the security of machine learning and trustworthy artificial intelligence.	-	24	51
	108858 - TRUSTWORTHY AI ROBOTICS USE CASES	ING-INF/05	1	1 CFU CARATTERIZZANTI Ingegneria Informatica	Specific use cases on the evaluation of the security of the object recognition system of the iCub robot will be addressed. Students will also get ability to answer open-ended questions with closed books, solve numerical exercises, use open-source libraries for the security evaluation of machine learning algorithms used by modern robots.	-	8	17
104737	VIRTUAL REALITY FOR ROBOTICS	ING-INF/05	4	4 CFU CARATTERIZZANTI Ingegneria Informatica	Starting from the knowledge on the fundamentals of graphics, modelling 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

4 CFU tra i seguenti insegnamenti:

80192	ADVANCED MODELLING AND SIMULATION TECHNIQUES FOR ROBOTS	ING-IND/13	4	4 CFU AFFINI O INTEGRATIVE Attività Formative Affini o Integrative	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
66044	FLEXIBLE AUTOMATION	ING-IND/13	4	4 CFU AFFINI O INTEGRATIVE Attività Formative Affini o Integrative	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. In greater detail, design and development techniques are proposed for intelligent flexible automation of industrial production systems with a view to Factory 4.0.	-	32	68
109205	SOFT ROBOTICS	ING-IND/13	4	4 CFU AFFINI O INTEGRATIVE Attività Formative Affini o Integrative	The course explores how compliance in the robot body can be exploited for dealing with task and environment uncertainty and for interacting with humans. “Softness” offers higher safety, larger variability of movement and higher dexterity and shows the potential for building safer, cheaper and more intelligent autonomous robots than conventional robotics can achieve. Taking inspiration from biological systems, which are able to survive in complex and unstructured environments thanks to the intrinsic compliance of their soft and flexible body, the focus is in understanding the mechanisms at the base of their high adaptability and in replicating them in robots for achieving intelligent behaviour. In particular the role of body morphology (i.e., form and structure), how biological systems use their body to control basic actions, and how intelligent behaviour emerges from the interaction between the body and the environment in which it is placed, constitute the foundation of the design of new soft actuators and sensors and new control strategies for the robot of the future.	-	32	68

12 CFU tra i seguenti insegnamenti:

80188	AMBIENT INTELLIGENCE	ING-INF/05	4	4 CFU AFFINI O INTEGRATIVE Attività Formative Affini o Integrative	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
98454	BIOMEDICAL ROBOTICS	ING-INF/06	4	4 CFU AFFINI O INTEGRATIVE Attività Formative Affini o Integrative	The purpose of this course is to provide a perspective on robotic technologies applied to (and inspired by) themes of biomedical research and practice. The first part of the course is intended to offer a background on biological signals and their applications in human-machine interfaces. The second part is devoted to in-depth analysis of specific applications. These include basic research in sensory-motor systems, advanced surgical and diagnostic techniques, body and brain machine interfaces, robots for assistance and rehabilitation, prosthetics, biomimetic robotics	-	32	68
98457	COOPERATIVE ROBOTICS	ING-INF/04	4	4 CFU AFFINI O INTEGRATIVE Attività Formative Affini o Integrative	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
108964	DESIGN OF AUTOMATIC MACHINERY AND ROBOTS	ING-IND/15	4	4 CFU AFFINI O INTEGRATIVE Attività Formative Affini o Integrative	To provide, by means of theoretical concepts and project-based learning, the knowledge of those engineering methods required to develop a project of industrial automation: from functionality identification to the integrated design of mechanical structure and actuation subsystem. The course is composed of lectures and lab exercises (by means of a dedicated CAD/CAE software tool)	-	32	68
80190	EMBEDDED SYSTEMS	ING-INF/04	4	4 CFU AFFINI O INTEGRATIVE Attività Formative Affini o Integrative	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
106723	EXPERIMENTAL ROBOTICS LABORATORY	ING-INF/05	4	4 CFU AFFINI O INTEGRATIVE Attività Formative Affini o Integrative	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
108861	INTRODUCTION TO QUANTUM INFORMATION AND COMPUTATION FOR ROBOTICS	FIS/02	4	4 CFU AFFINI O INTEGRATIVE Attività Formative Affini o Integrative	This course aims to introduce the key concepts and methods of Quantum Information and Computation. The first part will provide the operational elements of quantum mechanics and quantum information: superposition principle, quantum entanglement, the quantum bit (qubit) and quantum logical gates. The second part will introduce the basic quantum algorithms and applications to informatics such as quantum database search algorithm, quantum teleportation and superdense coding. The final part will deal with some possible applications to robotics. It will be shown as the above ideas and concepts can be introduced in software architecture for robots that exploit quantum-inspired perception, reasoning and action techniques.	-	32	68
86746	ITALIAN LANGUAGE (FOR FOREIGN STUDENTS) - BRIEF	L-FIL-LET/12	4	4 CFU AFFINI O INTEGRATIVE Attività Formative Affini o Integrative	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
52164	ITALIAN LANGUAGE (FOR FOREIGN STUDENTS) - LONG	L-FIL-LET/12	5	5 CFU AFFINI O INTEGRATIVE Attività Formative Affini o Integrative	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

108856	LINGUISTICS AND PHYLOSOPHY OF LANGUAGE	M-PSI/01	4	4 CFU AFFINI O INTEGRATIVE Attività Formative Affini o Integrative	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
104855	MACHINE LEARNING FOR ROBOTICS II	ING-INF/05	4			-	32	68
	86798 - MACHINE LEARNING AND DATA ANALYSIS	ING-INF/05	3	3 CFU AFFINI O INTEGRATIVE Attività Formative Affini o Integrative	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
	104856 - ROBOTICS USE CASES	ING-INF/05	1	1 CFU AFFINI O INTEGRATIVE Attività Formative Affini o Integrative	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
104749	PSYCHOLOGY OF PERCEPTION AND ACTION	M-PSI/01	4	4 CFU AFFINI O INTEGRATIVE Attività Formative Affini o Integrative	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
94866	SOCIAL ROBOTICS	ING-INF/05	4	4 CFU AFFINI O INTEGRATIVE Attività Formative Affini o Integrative	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 behaviour; 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
80186	SYSTEM IDENTIFICATION	ING-INF/04	4	4 CFU AFFINI O INTEGRATIVE Attività Formative Affini o Integrative	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.	-	32	68
108857	TRUSTWORTHY ARTIFICIAL INTELLIGENCE FOR ROBOTICS		4			-	-	-
	108606 - TRUSTWORTHY ARTIFICIAL INTELLIGENCE	ING-INF/05	3	3 CFU AFFINI O INTEGRATIVE Attività Formative Affini o Integrative	The aim of this course is to provide students with fundamental and advanced concepts on the security of machine learning and trustworthy artificial intelligence.	-	24	51
	108858 - TRUSTWORTHY AI ROBOTICS USE CASES	ING-INF/05	1	1 CFU AFFINI O INTEGRATIVE Attività Formative Affini o Integrative	Specific use cases on the evaluation of the security of the object recognition system of the iCub robot will be addressed. Students will also get ability to answer open-ended questions with closed books, solve numerical exercises, use open-source libraries for the security evaluation of machine learning algorithms used by modern robots.	-	8	17
104737	VIRTUAL REALITY FOR ROBOTICS	ING-INF/05	4	4 CFU AFFINI O INTEGRATIVE Attività Formative Affini o Integrative	Starting from the knowledge on the fundamentals of graphics, modelling 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