POLYTECHNIC SCHOOL
Master's Degree Programme 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 Didactic Regulations (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 Didactic Regulations, 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 the case of degrees other than those indicated above, the DPB verifies the presence of the curricular requirements or equivalent knowledge, based on the exams taken by the student in the degree course of origin, as well as the presence of any extra-curricular exams, internship activities and work experience gained.

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.

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 Degree Programme Table.

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

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

qualifications).

The Notice for Admission to the Polytechnic School's Master's Degree Courses and the website of the 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 11thof 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. Incompatibility for simultaneous enrolment
Referring to the Degree Programme Table of the cohort of this document, the Master Course in Robotics Engineering is recognized as incompatible for simultaneous enrolment with any LM32 course and with the following Master Courses of the University of Genoa:

- Computer Science

For other study courses belonging to different classes, including those of other universities, the compatibility analysis will be carried out as follows (DM 930/2022 and subsequent ministerial clarifications):
Initially, the basic and characterizing scientific disciplinary sectors of the two courses of study are considered. If the credits in common are more than 40, the two courses are incompatible for simultaneous enrolment. If from the previous analysis it appears that the credits in common are less than 40, the analysis of the learning outcomes and of further available information on the content of each teaching unit will be carried out to highlight common topics covered in courses characterized by different scientific disciplinary sectors. If even after this analysis the credits in common are less than 40, the two courses are declared compatible for simultaneous enrolment. In the event of the presence of several curricula, the calculation will be made in the least favourable case, i.e. the one characterized by the greatest number of common credits.

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

Art. 4. Training activities

The list of teaching units and other possible training activities, in the cohort 2023-2025, is given in the appropriate annex (Annex 1) which constitutes an integral part of this regulation.

One professor is appointed as responsible for each teaching unit.

The appointed professor is whoever is in charge of the teaching according to the law, or whoever the DPB has given this responsibility when assigning teaching tasks to professors.

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

Art. 5. Enrolment in individual training activities

In accordance with Article 5 of the University Regulations for students, in order to enrol in individual training activities you must have a qualification which allows access to the university.

Art. 6. Curricula

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

Art. 7. 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 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. 8. Study plans and prerequisites

Students must enrol full-time.

Each student carries out his training activity following a study plan which shall be in line with the Degree Programme Table provided by the Master's degree course in Robotics Engineering, which is distinguished by years of the course programme and published on the website. The study plan formulated by the students must contain an indication of the training activities, with the relative credits that they intend to achieve, provided by the official programme table for this teaching period, from a minimum of 45 credits up to a maximum of 65 provided in each year. The educational path of the student can be organised according with criteria of 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. 9. 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 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 Degree Programme website before the start of the lessons of the academic year.

The schedule of classes guarantees the possibility of attendance based on the years of the course programme provided for by the current Degree Programme Table. 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. 10. Examinations and other profit exams

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 students with different abilities and students with specific learning disorders (D. S. A.), in accordance withart. 20 paragraph 4 of the University Didactic Regulations.

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

The committees for profit examinations are appointed by the Director of the Department or by delegation by the Degree programme coordinator 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. 11. Recognition of credits

The Degree Programme Board 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 Didactic Regulations, 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 education/work alternance, it is possible for the Degree programme board to provide, for selected students, learning paths that also take into account work experience carried out at companies under contract.

Art. 12. Mobility, studies abroad, international exchanges

The DPB strongly supports the student mobility, in particular through participation to mobility and

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

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 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 students at the time of the compilation of the plan of training activities they intend to follow at the University abroad, must produce suitable documentation proving the equivalence of content between the teaching unit abroad and the teachingunit that they intend to replace taught in the Master's Degree Course in Robotics Engineering. Equivalence shall be evaluated by the DPB. The conversion of marks will take place according to criteria approved by the DPB, in accordance with EMARO and JEMARO grade system and European ECTS system.

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. 13. 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 defence by the candidate, whether the candidate will graduate quickly, and whether or not the candidate has acquired credits abroad. In particular:

1. The exams score E is calculated by taking into account the average grade of exams taken in Italy, and the average grade of exams taken abroad, each one weighted by the corresponding number of ECTS. The grade of exams taken abroad is adjusted by a coefficient F and capped at 30.
2. The Committee assigns a thesis score T on a scale of 100 as evaluation of the thesis and its discussion. The Committee also assigns a numerical bonus B1 on a scale from 0 to 5 using the same criteria.
3. The thesis score T (in thirtieths) is averaged, with weight 30 ECTS, with the exams score E, with weight equal to the number of ECTS taken by the student in their career. This value constitutes the career score C.
4. The Committee assigns a numerical bonus B2 equal to 1 if the student graduates within the last graduation session of the second academic year.

The graduation score G is calculated by adding the bonuses B1 and B2 to the career score C based on 110. The coefficient F enhances periods of study abroad, while the numerical bonus B2 enhances a student's ability to graduate within the academic year.

Art. 14. 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. 15. Verification of obsolescence of credits

Credits acquired within the framework of the Master's Degree course in Robotics Engineering are valid for 6 years. After the indicated period, the credits must be validated by special resolution if the DPB recognises the non-obsolescence of the related educational contents. If the DPB recognizes the obsolescence of even a single part of the relative educational content, the DPB itself establishes the supplementary tests that must be taken by the student, defining the topic and the methods of verification. Once the required tests have been passed, the DPB validates the credits acquired with a resolution. If the related training activity provides for a vote, it may be varied from the one previously obtained, on a proposal from the Examination Committee which carried out the verification.

Art. 16. 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 Degree Programme Board on 4th May 2023 and of the DIBRIS Department Board on 16th May 2023

DEGREE REGULATION - Special part

List of training activities and related training objectives
1st year (Cohort 2023-2024)

Course Code	Course name	ECTS	SSD (Disciplinary Scientific Area)	Type	Area	Learning Objectives	Hours dedicated to assisted teaching activities	Hours dedicated to personal study
56846	MODELING AND CONTROL OF MANIPULATORS	6	ING-INF/04	CORE	Computer Engineering	This course presents the fundamentals of the kinematics modelling and control techniques of serial manipulators. Topics include geometric modelling, task jacobian matrices, inverse kinematics, and closed loop kinematics control.	48	102
80514	MECHANICS OF MECHANISMS AND MACHINES	5	ING-IND/13	RELATED OR SUPPLEMENTARY	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 ACTIVITIES	Training and orientation activities	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 ACTIVITIES	Training and orientation activities	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 ECTS among following courses:

86736	ADVANCED AND ROBOT PROGRAMMING	5	ING-INF/05	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). State-of-the-art programming languages are used in coding, in particular C and rust.	40	85
104734	ARTIFICIAL INTELLIGENCE FOR ROBOTICS I	5	ING-INF/05	CORE	Computer Engineering	The goal of the course is to provide the foundations of knowledge-based intelligent autonomous agents.	40	85
104731	ARTIFICIAL INTELLIGENCE FOR ROBOTICS II	5	ING-INF/05	CORE	Computer Engineering	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
86805	COGNITIVE ARCHITECTURES FOR ROBOTICS	5	ING-INF/05	CORE	Computer Engineering	Robots are multi-purpose, multi-form and multi-function machines. Next-generation robots are expected to exhibit completely new and unique behaviours with respect to current machines, specifically in terms of what they are meant to do, how they are structured, and what they are capable to do. In order to cope with this diversity in form and function, cognitive architectures for robots must designed to allow robots to perceive their environments, make sense of it, employing various knowledge representation and reasoning models, and then act effectively on their environment. The course will address all relevant topics in a research-oriented way.	40	85

80181	CONTROL OF LINEAR MULTI-VARIABLE SYS.	5	ING-INF/04	CORE	Computer Engineering	The objective 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 systems, 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
80190	EMBEDDED SYSTEMS	5	ING-INF/04	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.	40	85
80158	HUMAN COMPUTER INTERACTION	5	ING-INF/05	CORE	Computer Engineering	The course provides the student with the methodology, the theory, and the techniques for the design of interactive products to support the way people communicate and interact in their everyday and working lives. This relies on the mastery of the development process for the understanding of the capabilities and desires of people and on the kinds of technology available to interaction designers, together with a knowledge of how to identify requirements and develop them into a suitable design. The course will cover standard techniques as well as an introduction to advanced topics, including sound and music computing (as a complementary component of visual and haptic interfaces), and emotional and social interfaces.	40	85

						A coursework devoted to the realization of the development process of a concrete interaction design project of an interactive product will be implemented during the whole semester, in a simulated working environment typical of Startups. Further, students will learn to design and manage motion capture sessions using the Qualisys industry standard motion capture system available at Casa Paganini-InfoMus. Finally, students will learn techniques to present their results, including elevator pitches and reporting to stakeholders.		
106956	MOBILE ROBOTS	5	ING-INF/04	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	5	ING-INF/05	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	5	ING-INF/04	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	40	85

						control), humans (e.g. human robot collaborative tasks).		
111106	SYSTEM IDENTIFICATION	5	ING-INF/04	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.	40	85

10 ECTS among following courses:

86735	COMPUTER VISION	5	INF/01	ELECTIVE	Chosen by the student	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	4	L-FIL-LET/12	ELECTIVE	Chosen by the student	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	5	L-FIL-LET/12	ELECTIVE	Chosen by the student	The course allows the student to achieve a sufficient oral and written comprehension	50	75

						of the local language, as well as an introduction to country culture.		
86928	MACHINE LEARNING FOR ROBOTICS I	5	INF/01	ELECTIVE	Chosen by the student	The course introduces the basics of Machine Learning and Artificial Neural Networks, as well as other well-known techniques 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	5	ING-IND/13	ELECTIVE	Chosen by the student	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	5	MAT/09	ELECTIVE	Chosen by the student	The Course presents methodological and computational aspects of optimization methods for the solution of a variety of problems, with particular attention to models and tasks arising in Robotics Engineering. Algorithms and software tools are illustrated. The lectures are 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. Several case-studies from Robotics are considered and solved by means of the described algorithms and available software	40	85
105038	SIGNAL PROCESSING IN ROBOTICS	5	ING-IND/31	ELECTIVE	Chosen by the student	The goal of the course is to provide the basic notions for the design of analog (both passive and active) and digital filters tailored for processing sensor measurements in robotic applications. 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

2° year (Cohort 2023-2024)

Course Code	Course name	ECTS	SSD (Disciplinary Scientific Area)	Type	Area	Learning Objectives	Hours dedicated to assisted teaching activities	Hours dedicated to personal study
60452	MASTER THESIS	30		FINAL EXAMINATION	For the 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	1	ING-IND/13	RELATED OR SUPPLEMENTARY	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 ECTS among following courses:

80188	AMBIENT INTELLIGENCE	4	ING-INF/05	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	4	ING-INF/04	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	32	68

						freedom. The framework is extended to the case where multiple robots need to work together, for example to manipulate and transport objects cooperatively.		
80190	EMBEDDED SYSTEMS	4	ING-INF/04	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	4	ING-INF/05	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	4	ING-INF/05	CORE	Computer Engineering		0	0
86798	MACHINE LEARNING AND DATA ANALYSIS	3	ING-INF/05	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	1	ING-INF/05	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	4	ING-INF/05	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 behaviours; sensors for human-robot interaction; methodology and constraints in making experiments with robots and human participants; application scenarios. The	32	68

						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.		
108857	TRUSTWORTHY ARTIFICIAL INTELLIGENCE FOR ROBOTICS	4		CORE	Computer Engineering		0	0
108606	TRUSTWORTHY ARTIFICIAL INTELLIGENCE	3	ING-INF/05	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.	28	47
108858	TRUSTWORTHY AI ROBOTICS USE CASES	1	ING-INF/05	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.	12	13
104737	VIRTUAL REALITY FOR ROBOTICS	4	ING-INF/05	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 **ECTS among following courses:**

80192	ADVANCED MODELLING AND SIMULATION TECHNIQUES FOR ROBOTS	4	ING-IND/13	RELATED OR SUPPLEMENTARY	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	4	ING-IND/13	RELATED OR SUPPLEMENTARY	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	4	ING-IND/13	RELATED OR SUPPLEMENTARY	Related or supplementary learning activity	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	32	68

						the design of new soft actuators and sensors and new control strategies for the robot of the future. This course will present different aspects of soft robotics technologies including, materials, manufacturing, actuation and sensing mechanisms, modelling and control and real-world applications.		

12 **ECTS among following courses:**

80188	AMBIENT INTELLIGENCE	4	ING-INF/05	RELATED OR SUPPLEMENTARY	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	4	ING-INF/06	RELATED OR SUPPLEMENTARY	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	4	ING-INF/04	RELATED OR SUPPLEMENTARY	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
80190	EMBEDDED SYSTEMS	4	ING-INF/04	RELATED OR SUPPLEMENTARY	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	32	68

						control applications, with a particular attention on peripheral configuration, real time and event-based programming techniques.		
106723	EXPERIMENTAL ROBOTICS LABORATORY	4	ING-INF/05	RELATED OR SUPPLEMENTARY	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	4	FIS/02	RELATED OR SUPPLEMENTARY	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
52164	ITALIAN LANGUAGE (FOR FOREIGN STUDENTS) - LONG	5	L-FIL-LET/12	RELATED OR SUPPLEMENTARY	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
86746	ITALIAN LANGUAGE (FOR FOREIGN STUDENTS) - BRIEF	4	L-FIL-LET/12	RELATED OR SUPPLEMENTARY	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
104855	MACHINE LEARNING FOR ROBOTICS II	4	ING-INF/05	RELATED OR SUPPLEMENTARY	Related or supplementary learning activity		0	0
86798	MACHINE LEARNING AND DATA ANALYSIS	3	ING-INF/05	RELATED OR SUPPLEMENTARY	Related or supplementary learning activity	Students will be provided with advanced skills related to machine learning and data analysis with particular reference to the	24	51

						statistical learning theory and its application to real world problems. Students will learn practical and theoretical insights on machine learning and data analysis methodologies.		
104856	ROBOTICS USE CASES	1	ING-INF/05	RELATED OR SUPPLEMENTARY	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	4	M-PSI/01	RELATED OR SUPPLEMENTARY	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
111072	SMART COUPLED SYSTEMS FOR SENSING AND ACTUATION	4	ING-IND/12	RELATED OR SUPPLEMENTARY	Related or supplementary learning activity	Students will learn how to model the transducers based on smart materials (e.g., shape memory alloys, piezoelectric, electromagnetic) and their interaction with the hosting structure, as well as how to test and characterize the systems experimentally. They will be able to model and test coupled systems. They will be acquainted with the material peculiarities, their main sensing/actuation features as well as their use in practical applications. Moreover, they will be aware of their possible advanced use in mechanical systems in which the material properties are exploited in the context of multi-domain interaction with the hosting structure (e.g., vibration attenuation, monitoring, energy harvesting, adaptability).	32	68
94866	SOCIAL ROBOTICS	4	ING-INF/05	RELATED OR SUPPLEMENTARY	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	32	68

						design of social robots; anthropomorphic and zoomorphic robots and robot behaviours; sensors for human-robot interaction; methodology and constraints in making experiments with robots and human participants; application scenarios. The student will face these problems both from a theoretical perspective and through practical assignments, by exploring in depth one of the topics above on real robots for social interaction.		
108857	TRUSTWORTHY ARTIFICIAL INTELLIGENCE FOR ROBOTICS	4		RELATED OR SUPPLEMENTARY	Related or supplementary learning activity		0	0
108606	TRUSTWORTHY ARTIFICIAL INTELLIGENCE	3	ING-INF/05	RELATED OR SUPPLEMENTARY	Related or supplementary learning activity	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	1	ING-INF/05	RELATED OR SUPPLEMENTARY	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	4	ING-INF/05	RELATED OR SUPPLEMENTARY	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.

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.

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.

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.

La data di scadenza per l'iscrizione è il 11 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

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

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 Incompatibilità per l'iscrizione simultanea
In riferimento all'offerta formativa per la coorte a cui questo regolamento si riferisce, il Corso di Studio in Robotics Engineering è riconosciuto incompatibile per l'iscrizione simultanea a qualsiasi corso LM32 e con i seguenti Corsi di studio dell'Università di Genova:

- Computer Science

Per altri corsi di studio appartenenti a classi diverse, compresi quelli di altre università, l'analisi di compatibilità sarà effettuata come segue (DM 930/2022 e successivi chiarimenti ministeriali):
Inizialmente, vengono considerati i settori disciplinari scientifici caratterizzanti dei due corsi di studio. Se i crediti in comune sono più di 40, i due corsi sono incompatibili per l'iscrizione simultanea. Se dall'analisi precedente risulta che i crediti in comune sono meno di 40, l'analisi dei risultati di apprendimento e di ulteriori informazioni disponibili sul contenuto di ogni unità didattica sarà effettuata per evidenziare gli argomenti comuni trattati in corsi caratterizzati da diversi settori disciplinari scientifici. Se anche dopo questa analisi i crediti in comune sono inferiori a 40, i due corsi sono dichiarati compatibili per l'iscrizione simultanea. In caso di presenza di più curricula, il calcolo sarà effettuato nel caso meno favorevole, ossia quello caratterizzato dal maggior numero di crediti comuni.

Art. 4. Attività formative
L'elenco degli insegnamenti e delle altre attività formative attivabili nella coorte 2023-2025 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. 5. 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. 6. Curricula
Il Corso di Laurea Magistrale non è articolato in curricula.

Art. 7. 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. 8. 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. 9. 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. 10. 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 con disabilità 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. 11. 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. 12. 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. 13. 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 difesa da parte del candidato, del fatto che il candidato si laureerà in tempi brevi e del fatto che il candidato abbia o meno acquisito crediti all'estero. In particolare:

1. Il punteggio degli esami E è calcolato tenendo conto del voto medio degli esami sostenuti in Italia e del voto medio degli esami sostenuti all'estero, ciascuno ponderato per il corrispondente numero di CFU. Il voto degli esami sostenuti all'estero è corretto da un coefficiente F e ha un limite massimo di 30.
2. La Commissione assegna un punteggio T su una scala di 100 come valutazione della tesi e della sua discussione. La Commissione assegna anche un bonus numerico B1 su una scala da 0 a 5 sulla base degli stessi criteri.
3. Il punteggio di tesi T (in trentesimi) viene mediato, con un peso di 30 ECTS, con il punteggio degli esami E, con un peso pari al numero di ECTS sostenuti dallo studente nella sua carriera. Questo valore costituisce il punteggio della carriera C.
4. La Commissione assegna un bonus numerico B2 pari a 1 se lo studente si laurea entro l'ultima sessione di laurea del secondo anno accademico.

Il voto di laurea G si calcola sommando i bonus B1 e B2 al punteggio della carriera C convertito in centodecimi. Il coefficiente F valorizza i periodi di studio all'estero, mentre il bonus numerico B2 valorizza la capacità dello studente di laurearsi entro l'anno accademico.

Art. 14. 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. 15. 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. 16. 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 4 maggio 2023 e con Delibera del Consiglio di Dipartimento DIBRIS del 16 maggio 2023.

REGOLAMENTO DIDATTICO – Parte Speciale

Elenco delle Attività formative e dei relativi obiettivi formativi

1° anno (coorte 2023/2024)

Codice Insegnamento	Nome Insegnamento	CFU	SSD	Tipologia	Settore	Obiettivi Formativi	Ore riservate alla didattica assistita	Ore riservate allo studio personale
56846	MODELING AND CONTROL OF MANIPULATORS	6	ING-INF/04	CARATTERIZZANTI	Ingegneria Informatica	This course presents the fundamentals of the kinematics modeling and control techniques of serial manipulators. Topics include geometric modeling, task jacobian matrices, inverse kinematics, and closed loop kinematics control.	48	102
80514	MECHANICS OF MECHANISMS AND MACHINES	5	ING-IND/13	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		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		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	25	100

						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.		

30 CFU tra i seguenti insegnamenti:

86736	ADVANCED AND ROBOT PROGRAMMING	5	ING-INF/05	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). State-of-the-art programming languages are used in coding, in particular C and rust.	40	85
104734	ARTIFICIAL INTELLIGENCE FOR ROBOTICS I	5	ING-INF/05	CARATTERIZZANTI	Ingegneria Informatica	The goal of the course is to provide the foundations of knowledge-based intelligent autonomous agents.	40	85
104731	ARTIFICIAL INTELLIGENCE FOR ROBOTICS II	5	ING-INF/05	CARATTERIZZANTI	Ingegneria Informatica	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
86805	COGNITIVE ARCHITECTURES FOR ROBOTICS	5	ING-INF/05	CARATTERIZZANTI	Ingegneria Informatica	Robots are multi-purpose, multi-form and multi-function machines. Next-generation robots are expected to exhibit completely new and unique behaviors with respect to	40	85

						current machines, specifically in terms of what they are meant to do, how they are structured, and what they are capable to do. In order to cope with this diversity in form and function, cognitive architectures for robots must designed to allow robots to perceive their environments, make sense of it, employing various knowledge representation and reasoning models, and then act effectively on their environment. The course will address all relevant topics in a research-oriented way.		
80181	CONTROL OF LINEAR MULTI-VARIABLE SYS.	5	ING-INF/04	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
80190	EMBEDDED SYSTEMS	5	ING-INF/04	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.	40	85
80158	HUMAN COMPUTER INTERACTION	5	ING-INF/05	CARATTERIZZANTI	Ingegneria Informatica	The course provides the student with the methodology, the theory, and the	40	85

						techniques for the design of interactive products to support the way people communicate and interact in their everyday and working lives. This relies on the mastery of the development process for the understanding of the capabilities and desires of people and on the kinds of technology available to interaction designers, together with a knowledge of how to identify requirements and develop them into a suitable design. The course will cover standard techniques as well as an introduction to advanced topics, including sound and music computing (as a complementary component of visual and haptic interfaces), and emotional and social interfaces. A coursework devoted to the realization of the development process of a concrete interaction design project of an interactive product will be implemented during the whole semester, in a simulated working environment typical of Startups. Further, students will learn to design and manage motion capture sessions using the Qualisys industry standard motion capture system available at Casa Paganini-InfoMus. Finally, students will learn techniques to present their results, including elevator pitches and reporting to stakeholders.		
106956	MOBILE ROBOTS	5	ING-INF/04	CARATTERIZZANTI	Ingegneria Informatica	The class first develops the kinematic modeling and motorization of mobile robots, illustrated by the full study of the differential drive robot. Then localization based on the Extended Kalman Filter is addressed, is illustrated by a lab which uses real data and presents a tuning methodology. Observability issues are also	40	85

						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.		
80169	REAL-TIME OPERATING SYSTEMS	5	ING-INF/05	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	5	ING-INF/04	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 environoment (e.g. force control), humans (e.g. human robot collaborative tasks).	40	85
111106	SYSTEM IDENTIFICATION	5	ING-INF/04	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	40	85

						addressed and their connections with control and identification are considered.		

10 CFU tra i seguenti insegnamenti:

86735	COMPUTER VISION	5	INF/01	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	4	L-FIL-LET/12	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	5	L-FIL-LET/12	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	5	INF/01	A SCELTA	A Scelta dello Studente	The course introduces the basics of Machine Learning and Artificial Neural Networks, as well as other well-known techniques 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	40	85

						mention will be made to the use of ANNs as static systems for information coding, and dynamical systems for optimization and identification.		
80183	MECHANICAL DESIGN METHODS IN ROBOTICS	5	ING-IND/13	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	5	MAT/09	A SCELTA	A Scelta dello Studente	The Course presents methodological and computational aspects of optimization methods for the solution of a variety of problems, with particular attention to models and tasks arising in Robotics Engineering. Algorithms and software tools are illustrated. The lectures are 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. Several case-studies from Robotics are considered and solved by means of the described algorithms and available software	40	85
105038	SIGNAL PROCESSING IN ROBOTICS	5	ING-IND/31	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 tailored for processing sensor measurements in robotic applications. 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

2° anno (Coorte 2023-2024)

Codice Insegnamento	Nome Insegnamento	CFU	SSD	Tipologia	Settore	Obiettivi Formativi	Ore riservate alla didattica assistita	Ore riservate allo studio personale
60452	MASTER THESIS	30		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	1	ING-IND/13	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	4	ING-INF/05	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	4	ING-INF/04	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	4	ING-INF/04	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	4	ING-INF/05	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	4	ING-INF/05	CARATTERIZZANTI	Ingegneria Informatica		0	0
86798	MACHINE LEARNING AND DATA ANALYSIS	3	ING-INF/05	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	1	ING-INF/05	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	4	ING-INF/05	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 behaviours; sensors for human-robot interaction; methodology and constraints in making experiments with robots and human participants; application scenarios. The student will face these problems both from a theoretical perspective and through practical assignments, by exploring in depth one of the topics above on real robots for social interaction.	32	68
108857	TRUSTWORTHY ARTIFICIAL INTELLIGENCE FOR ROBOTICS	4		CARATTERIZZANTI	Ingegneria Informatica		0	0
108606	TRUSTWORTHY ARTIFICIAL INTELLIGENCE	3	ING-INF/05	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.	28	47
108858	TRUSTWORTHY AI ROBOTICS USE CASES	1	ING-INF/05	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.	12	13
104737	VIRTUAL REALITY FOR ROBOTICS	4	ING-INF/05	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 /	32	68

						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).		

4 CFU tra i seguenti insegnamenti:

80192	ADVANCED MODELLING AND SIMULATION TECHNIQUES FOR ROBOTS	4	ING-IND/13	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	4	ING-IND/13	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	4	ING-IND/13	AFFINI O INTEGRATIVE	Attività Formative Affini o Integrative	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. This course will present different aspects of soft robotics technologies including, materials, manufacturing, actuation and sensing mechanisms, modeling and control and real-world applications.	32	68

12 CFU tra i seguenti insegnamenti:

80188	AMBIENT INTELLIGENCE	4	ING-INF/05	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	4	ING-INF/06	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	4	ING-INF/04	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
80190	EMBEDDED SYSTEMS	4	ING-INF/04	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	32	68

						programming for control applications, with a particular attention on peripheral configuration, real time and event-based programming techniques.		
106723	EXPERIMENTAL ROBOTICS LABORATORY	4	ING-INF/05	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	4	FIS/02	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
52164	ITALIAN LANGUAGE (FOR FOREIGN STUDENTS) - LONG	5	L-FIL-LET/12	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
86746	ITALIAN LANGUAGE (FOR FOREIGN STUDENTS) - BRIEF	4	L-FIL-LET/12	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

104855	MACHINE LEARNING FOR ROBOTICS II	4	ING-INF/05	AFFINI O INTEGRATIVE	Attività Formative Affini o Integrative		0	0
86798	MACHINE LEARNING AND DATA ANALYSIS	3	ING-INF/05	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	1	ING-INF/05	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	4	M-PSI/01	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
111072	SMART COUPLED SYSTEMS FOR SENSING AND ACTUATION	4	ING-IND/12	AFFINI O INTEGRATIVE	Attività Formative Affini o Integrative	Students will learn how to model the transducers based on smart materials (e.g., shape memory alloys, piezoelectric, electromagnetic) and their interaction with the hosting structure, as well as how to test and characterize the systems experimentally. They will be able to model and test coupled systems. They will be acquainted with the material peculiarities, their main sensing/actuation features as well as their use in practical applications.	32	68

						Moreover, they will be aware of their possible advanced use in mechanical systems in which the material properties are exploited in the context of multi-domain interaction with the hosting structure (e.g., vibration attenuation, monitoring, energy harvesting, adaptability).		
94866	SOCIAL ROBOTICS	4	ING-INF/05	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 behaviours; sensors for human-robot interaction; methodology and constraints in making experiments with robots and human participants; application scenarios. The student will face these problems both from a theoretical perspective and through practical assignments, by exploring in depth one of the topics above on real robots for social interaction.	32	68
108857	TRUSTWORTHY ARTIFICIAL INTELLIGENCE FOR ROBOTICS	4		AFFINI O INTEGRATIVE	Attività Formative Affini o Integrative		0	0
108606	TRUSTWORTHY ARTIFICIAL INTELLIGENCE	3	ING-INF/05	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	1	ING-INF/05	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	8	17

						of machine learning algorithms used by modern robots.		
104737	VIRTUAL REALITY FOR ROBOTICS	4	ING-INF/05	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