Automatic Control [2201137]

Offerta didattica a.a. 2024/2025

Docenti: GABRIELE OLIVA

Periodo: Secondo Ciclo Semestrale

Obiettivi formativi
Acquiring knowledge and understanding of methodological tools for the design of modern and multi-variable control algorithms, distributed algorithms and fuzzy control algorithms.
Ability to implement control algorithms and distributed algorithms considering issues related to the use of computers or micro-controllers, and providing tools for the state reconstruction based on limited and uncertain information.
Ability to implement fuzzy control algorithms.

Prerequisiti
Basilar elements of Control theory

Contenuti del corso
The course is taught in English and it is composed of 4 units, detailed below.
1) State Space Control (30%)
Systems of linear differential equations with constant coefficients. State-space representation.
Discretization of a continuous-time system.
State feedback control.
Controllability.
State feedback with assignment of the dynamics.
Optimal control techniques: optimal problems, Pontryagin principle, optimal linear quadratic control, Riccati equation.
Implementation of state feedback control algorithms via computer and/or microcontroller.
2) Filtering and state reconstruction (30%)
Observability.
State reconstruction via Luenberger observer.
Feedback based on State reconstruction
Filtering and state reconstruction problems.
Kalman filter.
Extended Kalman filter.
Implementation of filtering, estimation and output feedback control algorithms via computer and/or microcontroller.
3) Distributed Systems (25%)
Introduction to distributed systems and graphs
Distributed consensus algorithms
Formation control algorithms
Aynchoronous distributed algorithms based on Gossip protocols Implementation of distributed algorithms via computer and/or microcontroller.
4) Fuzzy Control (15%)
Introducton to soft-computing techniques with application to control. Principles of Fuzzy logic.
Fuzzy Expert Systems: inferential engines, rules, Mamdami and Takagi-Sugeno-Kang systems.
Fuzzy Control: fuzzy controllers in the control loop, fuzzyfication and defuzzyfication methods.
Implementation of Fuzzy control algorithms via computer and/or microcontroller.

Metodi didattici
Lectures presenting the topics of the course (60%).
Exercises and tutorials, using the blackboard, computer and by means of Intel Galileo Gen 2, Arduino, or similar microcontrollers (40%).

Modalità di verifica dell'apprendimento
Knowledge assessment methods and criteria:

Knowledge and understanding are assessed through a presentation illustrating the project and an oral interview.
Knowledge and applied understanding are assessed by developing a project to be carried out in small groups (2-4 students). The project concerns the implementation of control algorithms in Matlab and / or on microcontroller (Intel

Galileo Gen 2, Arduino or similar). This project can be assigned directly by the teacher, but students are invited to propose and with whom it reserves the right to carry out a feasibility check of the same.
The autonomy of judgment is assessed based on the projects, relative to the developed project, and based on the oral interview, during which a problem that can be solved in different ways can be submitted to the candidates.
Communication skills are assessed based on the presentation of the project and based on the oral interview, during which the ability of the candidates to argue and communicate about the topics of the course will be assessed.
The ability to learn will be assessed based on the oral interview, which will include questions that require not only critical thinking skills, but also knowledge of the analysis and control techniques of systems theory.

Criteria for measuring learning and defining the final grade:

The score is composed as follows: 20% project work, 80% oral exam. The oral exam consists of two-three questions, which can be theoretical (e.g., demonstrations or presentation of the features of control schemes) or practical (e.g., exercises).
At the discretion of the commission, the last question may be characterized by a high level of difficulty and, based on the answer, honors can be attributed.

Testi di riferimento

Handouts
Thomas Kailath, Linear Systems, Prentice-Hall, 1980.
Bonivento Melchiorri Zanasi, Sistemi di controllo digitale, Progetto Leonardo,1995
Additional Bibliography:
Passino, Kevin M., Stephen Yurkovich, and Michael Reinfrank. Fuzzy control. Vol. 42. Menlo Park, CA: Addison-wesley, 1998.
Franklin, Powell, Workman, Digital Control of Dynamic Systems, Addison-Wesley, 1998.
R. Setola, Tecniche di controllo a reazione di stato, dispense, 1997.
G. Marro, Controlli Automatici, Zanichelli, 2004.
Luenberger, Introduction to Dynamic Systems, John Weley & Sons, 1979. Bolzern, Scattolini, Schiavoni, Fondamenti di controlli automatici, McGrawwHill, 2004.
Aderson, Moore, Optimal Control – Linear Quadratic Methods, Prentice-Hall, 1989.
Cavallo, Setola, Vasca, Guida operativa a Matlab Simulink e Control Toolbox, 1995.
Michael Margolis e B. Sansone, Arduino. Progetti e soluzioni, O'reilly, 2013

Altre informazioni

The course aims at providing the following skills.
1) Knowledge and understanding: Methodological tools for the design of modern and multi-variable control algorithms, distributed algorithms and fuzzy control algorithms.
2)Applying knowledge and understanding: Ability to implement control algorithms and distributed algorithms considering issues related to the use of computers or micro-controllers, and providing tools for the state reconstruction based on limited and uncertain information. Ability to implement fuzzy control algorithms. 3)Making judgements: Ability to identify the most adequate control strategy, among those presented in the course, for solving complex problems such as the analysis and synthesis of control systems.
4) Communication skills: Ability to communicate with the instructor and the other students with respect to complex topics such as control theory. Ability to formulate questions and to provide answers in english.
5) Learning skills: The student will be guided in his learning process by means of a study methodology aimed at making productive the participation of the student to lessons and exercises. This will be obtained by the instructors via the participation and active involvement of the students during the lessons, since the student will have to solve problems with increasing degree of complexity during the course.

L'attività didattica è offerta in:

Facoltà Dipartimentale di Ingegneria

Tipo corso	Corso di studio (Ordinamento)	Percorso	Crediti	S.S.D.
Corso di Laurea Magistrale	Master of Science in Biomedical Engineering (2019)	e-Health Systems	6	ING-INF/04

Stampa del 07/05/2025

Automation and safety of working environments [2201229]

Offerta didattica a.a. 2024/2025

Docenti: ROBERTO SETOLA

Periodo: Primo Ciclo Semestrale

Obiettivi formativi

The aim of the course is to illustrate how to use automated solutions to improve the comfort and the safety of working environments in the Safety 4.0 context. Within the course, monitoring methods of the working environment and of the worker's state of health will be illustrated. The course is characterised by an integrated approach "Cyber-Physical Human Systems" where the physical and computer science elements are designed unitedly, taking into account the central importance of the human operator. Special attention will be given to innovative solutions based on the application of smart-devices and simple sensors as part of those solutions.

Prerequisiti

No requisites needed

Contenuti del corso

Program:
Part I (14 hours): Elements of risk analysis and management in the workplace, organisation and safety management models, safety measures.

Part II (20 hours): Worker well-being monitoring systems, activity recognition systems, IoT/IIoT technologies supporting operator safety in complex environments, methodologies and technological solutions for monitoring activities and tracking workers indoors and outdoors, definition and classification of personal protective equipment (PPE), PPE regulations. Process of sensorizing a PPE (e.g., helmet or mask) with an electronic board. Data analysis from a temperature sensor: data import techniques, filtering, signal segmentation, and extraction of direct/indirect parameters in Matlab. Fundamentals of machine learning: introduction to basic concepts and main applications in the context of workplace safety. Machine learning models: focus on Support Vector Machine (SVM) and Random Forest as practical examples.

Part III (14 hours): Industrial monitoring systems: PLC and SCADA. Plant monitoring systems, observer and Kalman Filter, Digital Twin. Elements of data fusion and situation awareness, Fault detection techniques.

Metodi didattici

Teaching methods
• Frontal classes with computer presentations (50% of the activity);
• Design exercise involving the students (40% of the activity);
• Seminars held by industrial experts (10% of the activity);

Modalità di verifica dell'apprendimento

Evaluation methods
The final grade is awarded on the basis of a procedure that includes 2 steps:
1. Exposure and discussion of the group project results. In this phase the clarity of exposure, communication skills and pertinence of the answers will be evaluated. The development of a prototypal solution encourages the use and the deepening of technological and methodological skills learned during the course and will cover a topic related to monitoring the activities performed by a worker.

2. An oral interview that aims at verifying the student's understanding of the theoretical foundations at the basis of the various design choices and the capability to assess risks and problems related to the use of a specific technological solution. To this end, each member of the examination committee will ask the student to illustrate an aspect related to the topics presented during the course.

Criteria for measuring learning and awarding the final grade
For the final evaluation, a weighted average will be made between the evaluation of the project paper (weight 60%) and the oral test (weight 40%). Honours are awarded by the committee to candidates who have achieved the

maximum score and proved in the context of the development of the project work or during the oral exam, a particular and detailed knowledge and understanding of the topics of the course.

Testi di riferimento

Reference texts

• Material provided by the teacher
• P. Chiacchio, F. Basile, “Tecnologie informatiche per l'automazione”, McGraw-Hill, 2004.
• P. Cerrani, “Guida essenziale alla sicurezza di macchine e impianti”, Tecniche Nuove; 1 edition
• E. Koç, “Internet of Things Applications for Enterprise Productivity”, Business Science Reference

Altre informazioni

Specific learning outcomes

• Knowledge and undestranding
Knowledge and understanding of potential risks and hazards for the workers’ safety in working environments. Knowledge of the basic methodological tools and automated solutions that can help reduce hazards and increase the well-being of the workers.

• Applying knowledge and understanding
Knowledge of designing and implementing simple monitoring solutions able to reduce the risk of occupational accidents in working environments.

• Making judgements
Capability to estimate risks and hazards in working environments.

• Communications skills
The course promotes the development of the students’ ability to work in team through the assignment of a design task. The main goal of the group work is to design a simple monitoring solution to be used in real work scenarios. Class participants are asked to discuss the proposed solution in a final presentation that helps the students ameliorate their communication skills, ability to synthesize and clarity of exposure.

• Learning skills
The course aims to develop learners' learning on-doing skills by confronting them with practical exercises of increasing difficulty that require creative effort as well as knowledge of the theoretical elements illustrated in the theoretical part of the course.

L'attività didattica è offerta in:

Facoltà Dipartimentale di Ingegneria

Tipo corso	Corso di studio (Ordinamento)	Percorso	Crediti	S.S.D.
Corso di Laurea Magistrale	Master of Science in Biomedical Engineering (2019)	Biorobotics and Ergonomics	6	ING-INF/04

Stampa del 07/05/2025

Biodesign [2201236]

Offerta didattica a.a. 2024/2025

Docenti: FABRIZIO TAFFONI

Periodo: Primo Ciclo Semestrale

Obiettivi formativi
The Biodesign class aims at providing students with the necessary competencies to: i) critically analyze a problem to derive technical specification in the mechanic, electronic and informatic domain, ii) develop different solution concepts and evaluate the best one; iii) produce technical reports which highlight their technical choices; iv) work in group to address a complex problem with time and budget constraints

Prerequisiti
Knowledge of the main features and components of mechatronic devices for biomedical applications;
Knowledge of the main design techniques of mechatronic devices and the main technologies for their fabrication.
C programming language (elementary level).
B1 level of English

Contenuti del corso
The course will be organized into 3 parts:
Part 1 (2CFU): Engineering design, presentation of the problem, definition of functional and technical specifications, theory review.
a) Engineering design
b) Presentation of the problem and definition of functional requirements
c) Elements of electronics and signal theory: signal conditioning and acquisition

Part 2 (2CFU): Presentation of the designing tools
a) Electronic CAD: applications to the design of electronic boards for signal conditioning and preparation of supporting documents
b) Mechanical CAD: static simulation and supporting documents
c) IDE for embedded modular programming: development and management of libraries.

Part 3 (2CFU): Development and simulation of the system's sub-components in the classroom with the teacher's and tutors' support. Drawing up of the final report.
a) Design and simulation of mechanical module
b) Design and simulation of the electronic module
c) System integration
d) Report production

Metodi didattici
The Biodesign class is a practical course based on the learning by doing principle. Students will be divided into groups (8 people max). They will be given a design issue and requested to produce a detailed description of its functional and technical specifications. Instructors will guide students providing them with suggestions about the most appropriate approach to follow.
The teaching activity will be held both in the classroom (32 hours) and in the laboratory (16 hours), under the teacher's and tutors' supervision. During the classroom activities students will be involved in frontal lessons (20 hours); exercises (6 hours); technical report drafting (6 hours). The lab activities will be focused on group exercises

Modalità di verifica dell'apprendimento
Knowledge and skills related to the course basics are tested through an examination that consists of both individual and group activities.
The individual test aims to assess how well the student is able to define functional and technical specifications, define an outline project, and identify and use the most suitable tools for its implementation. The test consists of a practical laboratory activity and of an oral exam.
The group theoretical/design test consists in the preparation of a technical report about the design work carried out by the group to address a specific problem applied to the biomedical field and of a presentation.

Testi di riferimento
Notes provided by the instructors

Altre informazioni
Knowledge and understanding: knowledge and understanding of the main applicative domains in which split a complex technical problem (mechanic, electronic, and informatic domains) in order to organize the work into elementary tasks according to concurrent engineering methodology.
Applying knowledge and understanding: capacity to derive technical specification from a vague problem, to autonomously identify and select the mechanic and electronic components necessary to address a technical problem and to prepare a Bill of Material (BoM)
Making judgements: students will learn a method to take designing choices in presence of limited or incomplete information.
Communication skills: capacity to communicate the designing activity in a clear and non-ambiguous way to technical as well as non-technical audience.
Learning skills: students will learn how to read and interpret a datasheet in order to autonomously select the components most appropriate to design a solution for a specific technical problem

L'attività didattica è offerta in:

Facoltà Dipartimentale di Ingegneria

Tipo corso	Corso di studio (Ordinamento)	Percorso	Crediti	S.S.D.
Corso di Laurea Magistrale	Master of Science in Biomedical Engineering (2019)	Common	6	ING-IND/34

Stampa del 07/05/2025

Rehabilitation Bioengineering [2201203]

Offerta didattica a.a. 2024/2025

Docenti: EUGENIO GUGLIELMELLI

Periodo: Primo Ciclo Semestrale

Obiettivi formativi

The course aims to provide to the student the following knowledge in the field of Rehabilitation Bioengineering:
• The main classifications, methodologies, tools and technologies for the evaluation of the impairment and of the consequent limitations and restrictions in the Activities of Daily Living (ADLs);
• Basis criteria for modelling the human component and for allocation of roles in relation to the human-technology cooperation and interaction for the application to technological aids;
• The key technological solutions for assisted rehabilitation and for enabling independent living and social inclusion.

Prerequisiti

None.
Suggested prior exams: Meccatronica per i Sistemi Biomedicali, Robotica Industriale e Medica.

Contenuti del corso

• Overview of the clinical aspects related to the rehabilitation process and to the role of technology (0.5 CFU)
• Human factors for rehabilitation bioengineering (0.5 CFU)
• Introduction to rehabilitation process: general characteristics, phases of treatment, evaluation principles of the rehabilitation outcome and analysis of the factors influencing the outcome (0.5 CFU)
• Technologies for robot-aided rehabilitation: general characteristics, definitions, state of the art, human-machine interaction, case studies (1 CFU)
• Aids and technologies for personal assistance: general characteristics, definitions, state of the art, case studies (1 CFU)
• Models for the interaction between aid, user, activity and context (1 CFU)
• Control interfaces for personal assistance (1 CFU)
• Interfaces for technical aids: general characteristics, functional architecture, selection set, methods and criteria, review of the main interface types (0.5 CFU)

Metodi didattici

Frontal lessons (4.5 CFU) during which the teacher will introduce course arguments.
Exercise classes (1CFU) aiming to show the application of the theoretical knowledge previously presented in frontal lessons.
Seminars (0.5 CFU) delivered by experts in the field (academia and industry).

Modalità di verifica dell'apprendimento

The exam consists of an oral test (maximum duration: 45 minutes).
The oral exam is both closed stimulus and open stimulus and with open response. During the oral exam, the teachers will ask three questions aimed at verifying students' knowledge of course topics.
All the questions have the same weight in the evaluation (i.e. 11 points for each).
The exam is passed if the candidate reaches a minimum grade of at least 18/30.
Honors will be given in case of full marks for all the examinations and a final grade higher than 30.

Testi di riferimento

• A.M. Cook, S.M. Hussey – Assistive technologies: principles and practices, Elsevier, 2015 (4th edition) cap 1-2-3-6-7.
• Xie, Shane. "Advanced robotics for medical rehabilitation." Springer tracts in advanced robotics 108.1 (2016). Cap: 1, 2, 4 – 7.
• A. Cappello, A. Cappozzo, P. E. Prampero – Bioingegneria della postura e del movimento, Pàtron, 2003
• D. Bonaiuti "Le scale di misura in riabilitazione", Seu editore, 2011. Capitolo: "Le scale di valutazione in riabilitazione.
• R. Cooper, H. Ohnabe, D.A. Hobson (Ed.s), An Introduction to Rehabilitation Engineering, CRC Press, 2007.
• der Loos, V., Machiel, H. F., Reinkensmeyer, D. J., & Guglielmelli, E. (2016). Rehabilitation and health care robotics. In Springer handbook of robotics (pp. 1685-1728). Springer, Cham.
• Slides used by teacher during frontal lessons, scientific papers and additional materials provided by teacher.

These materials will be shared on the course page of the UCBM e-Learning platform. Scientific paper for an in-depth analysis of themes and/or case studies provided by the teacher and tutors. These materials will be shared on the course page of the UCBM e-Learning platform.

Altre informazioni

Knowledge and understanding
• Methods and tools for biomechatronic, human-centred design of the variety of technological tools that bioengineering can offer for supporting the modern rehabilitative therapies for optimizing inclusion into the social life and in the working environment of patients with potentially disabling pathologies.
• State of the art and case studies on technologies, systems and machines for assisted therapy and for supporting independent living.

Ability to apply knowledge and understanding
• To know how to use methods, tools and technologies of bioengineering for modelling and assessing human performance and for allocation of roles for human-technology co-operation and interaction;
• To know how to use of technological tools that bioengineering can provide for the full recovery of the social and working life of a patient suffering from diseases which can reduce human abilities.
• To Know how to critically analyze and to understand the functioning and rationale of design, development and application of technologies for assistance to patients during the main phases of the rehabilitation process: evaluation of functional performance, clinical therapy for functional recovery and occupational therapy for social and working re-integration.

Making judgements
The students will be encouraged to develop their analytical and critical skills by proposing examples and applications regarding the theme introduced during frontal lessons.
Learning skills
The students will be actively involved during the frontal lessons and exercise classes. Practical examples in the field of Rehabilitation Bioengineering will be introduced to motivate the in-depth analysis of topics discussed during frontal lessons. During exercise classes, examples will be presented as applications to specific problems.

Communication abilities
Particular attention will be provided to the development of communication abilities by actively involving the student during the frontal lessons and exercise classes.

L'attività didattica è offerta in:

Facoltà Dipartimentale di Ingegneria

Tipo corso	Corso di studio (Ordinamento)	Percorso	Crediti	S.S.D.
Corso di Laurea Magistrale	Master of Science in Biomedical Engineering (2019)	Common	6	ING-IND/34

Stampa del 07/05/2025

Bioengineering and Biomechanics of the human motion [2201231]

Offerta didattica a.a. 2024/2025

Docenti: FRANCESCA CORDELLA

Periodo: Secondo Ciclo Semestrale

Obiettivi formativi

This course has the main purpose of introducing to the field of Bioengineering and Biomechanics of the Human Movement, with particular reference to the hand district. The student will be provided with: i) solid theoretical knowledge on kinematic analysis, on the study of interaction forces, on pose estimation methods and learning techniques for the study of human biomechanics; ii) practical bases for the analysis of biomechanics of motion. The theoretical topics will be accompanied by experimental activities that will aim to apply the theoretical aspects to practical cases.

Prerequisiti

None

Contenuti del corso

Introduction (4 hours):
• Role and competences of the biomedical engineer
• Application of biomechanical analysis to different fields (surgery, rehabilitation, assistance)
• From Biomechanics to Robotics
• Role of biofeedback in biomechanical analysis
• Biomechanical models

Systems and techniques for motion analysis (20 hours)
• Introduction to RGB and RGB-D systems (eye-camera parallel, Pinhole model, paraxial refraction model, camera calibration algorithms, epipolar geometry)
• Pose estimation methods (Kalman filter and its extensions)
• Object recognition through vision
• Learning techniques and application of these concepts to motion reconstruction

Motion analysis of the human hand (14 hours)
• The human hand
• Anatomy and functional properties
• Kinematic models and protocols of the human hand
• Centers and axes of rotation
• Theory of Grasping (grasp matrix, functionality and stability indices - force and form closure
• Semantic grasping

Sensori-motor control (10 hours)
• Theories on human motion control and learning
• Redundancy problem
• Postural synergies and introduction to evaluation tools

Metodi didattici

Lectures on the topics of the course (38 hours).
Classroom tutorials and laboratory sessions for the use of the analyzed theoretical-practical tools (MATLAB) (10 hours).
Group practical exercises where students will apply competencies acquired during the lectures. The groups will be composed of 5-6 students. They will be required to integrate the modules presented during the course.

Modalità di verifica dell'apprendimento

The knowledge and skills related to the topics of the course are verified in the following ways:
a) oral examination, on topics covered during the entire course. The verification will be based on the presentation by slides of the experimental work carried out and on the answer to questions on theoretical and practical topics about bioengineering, biomechanics and methods for analysis and modeling
b) presentation of practical exercises on integration of the modules presented during the course. Students' ability to

apply the methods of motion analysis, carried out with artificial vision systems, to a practical case will be tested.
The final grade of the student will be calculated as a weighted sum of the single grades for the practical exercises (25%) and the oral examination (75%). The praise is given to the students who have achieved the maximum score on all the tests (practical exercises and oral) with a final score higher than 30/30.
All the practical exercises will be presented and discussed at the end of the course and, however, before the first date of the oral exam. During the discussion, specific questions for each student of the same group will be asked in order to assess the individual contribution to the overall work.

Testi di riferimento

• Lecture notes distributed by the teacher.
• Nowak, D., & Hermsdörfer, J. (Eds.). (2009). Sensorimotor Control of Grasping: Physiology and Pathophysiology. Cambridge: Cambridge University Press. doi:10.1017/CBO9780511581267

Altre informazioni

Knowledge and understanding
• Fundamentals of bioengineering, biomechanics and of analysis and modeling methods
• Software tools for biomechanical analysis.
Applying knowledge and understanding
• Capability to apply methods and tools of mechanics, artificial intelligence, vision, systems theory to the analysis of human movement.
• Capability to use human movement analysis software tools.
Autonomy in judging
The student will be stimulated to develop their analytical and critical skills in understanding the theoretical concepts and in evaluating the results within the experimental activities carried out during the course.
Communication skills and soft skills
The course wants to promote the development of communication abilities and soft skills to work in team. This goal will be pursued by i) soliciting pro-active involvement of the students during the lectures, ii) working on group activities that require the implementation of practical exercises; ii) preparing reports on the experimental activities (by means of slides).
Learning ability
The students will have to develop an increasing ability to learn through a study methodology that makes the attendance to lessons productive (with reference to both theoretical topics and exercises) and allows an active participation in them. The course, by means of experimental activities, stimulates the transfer of the learnt concepts to specific application areas, in order to allow the development of the ability to apply and to contextualize methods and notions.

L'attività didattica è offerta in:

Facoltà Dipartimentale di Ingegneria

Tipo corso	Corso di studio (Ordinamento)	Percorso	Crediti	S.S.D.
Corso di Laurea Magistrale	Master of Science in Biomedical Engineering (2019)	Biorobotics and Ergonomics	6	ING-IND/34

Stampa del 07/05/2025

Biomaterials [2201222]

Offerta didattica a.a. 2024/2025

Docenti: ALBERTO RAINER

Periodo: Secondo Ciclo Semestrale

Obiettivi formativi
The course will provide students with the elements to understand the properties of biomaterials, i.e. materials to be employed in contact with biological tissues.

Prerequisiti
Basic knowledge in chemistry and materials science is recommended.

Contenuti del corso
Generalities (10h)
Biomaterials science: definition, applications, trends.
Biocompatibility: requirements, cell-biomaterial interaction, inflammation, repair, integration and failure processes, infection.
Biomaterials (18h)
Materials properties: mechanical, chemical and surface properties.
Biomaterials: metals, ceramics, polymers, natural materials.
Structure, properties, fabrication processes.
Biological tissues and biomechanics
Biomedical devices (20h)
Orthopedic implants, vascular grafts, cardiac valves, aesthetic prostheses.

Metodi didattici
Lectures introducing the course topics with “case studies” regarding the application of biomaterials to specific problems (e.g., orthopedic implants, vascular grafts, artificial valves) (40 h). Seminars/webinars by industry professionals in the field of biomaterials will strengthen the theoretical contents (8 h).

Modalità di verifica dell'apprendimento
Knowledge assessment methods and criteria
Knowledge will be assessed by means of a 2-hours written test with 3 open-ended questions.
The test aims to assess:
• Knowledge and understanding of the subject
• Capacity of applying knowledge and understanding to real world problems in the field of implantable devices
• Communication skills, such as the capacity to provide both specialistic and non-specialistic audience with unambiguous explainations
• Ability to autonomously perform materials choice in the design of implantable devices
• Ability to autonomously extend knowledge by accessing the literature

Criteria for measuring learning and defining the final grade
To get a pass, students should demonstrate sufficient knowledges of the course contents. Higher marks (above 27 out of 30) will be given to those students who possess excellent knowledge of the course contents and are able to correlate them in a logical way. Honors (lode) will be reserved to those students who obtain 30 out of 30 and show excellent presentation skills, using graphs and schemes.

Testi di riferimento
- Riccardo Pietrabissa. Biomateriali per protesi e organi artificiali. Patron Editore
- Handouts and selected publications available at http://elearning.unicampus.it
For each topic, students will be provided with a subsidiary list of relevant textbooks for deepening their knowledge.

Altre informazioni
Knowledge and understanding
• Knowledge of the physico-chemical properties of biomaterials
• Knowledge of the most relevant classes of implantable medical devices.

Applying knowledge and understanding
• Ability to design biomaterials-based implantable devices.

Making judgements
• Ability to autonomously perform requirements analysis for implantable medical devices from a biomaterials point of view.

Communication skills
• Ability to communicate with professionals in the field of biomaterials using a technical vocabulary

Learning skills
• Ability to autonomously extend knowledge by accessing the literature.

L'attività didattica è offerta in:

Facoltà Dipartimentale di Ingegneria

Tipo corso	Corso di studio (Ordinamento)	Percorso	Crediti	S.S.D.
Corso di Laurea Magistrale	Master of Science in Biomedical Engineering (2019)	Common	6	ING-IND/34

Stampa del 07/05/2025

Biomedical Research and Innovation Management and Assessment [2201145]

Offerta didattica a.a. 2024/2025

Docenti: LEANDRO PECCHIA

Periodo: Secondo Ciclo Semestrale

Syllabus non pubblicato dal Docente.

L'attività didattica è offerta in:

Facoltà Dipartimentale di Ingegneria

Tipo corso	Corso di studio (Ordinamento)	Percorso	Crediti	S.S.D.
Corso di Laurea Magistrale	Master of Science in Biomedical Engineering (2019)	Common	6	ING-INF/06

Stampa del 07/05/2025

Biomicrosystems [2201208]

Offerta didattica a.a. 2024/2025

Docenti: ENRICO DOMENICO LEMMA

Periodo: Secondo Ciclo Semestrale

Obiettivi formativi
The course will provide the students with the main theoretical and practical tools to properly project and realize (bio)microdevices. The addressed topics will be discussed from a cross-disciplinary perspective and will be based on the most recent developments reported in scientific literature.

Prerequisiti
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Contenuti del corso
Part 1: Fundamentals (8h)
- Basic concepts: resolution, dimensional analysis, scaling;
- elements of microfluidics;
- properties and processing of materials.

Part 2: Microtechnologies (40h)
- UV lithography;
- subtractive (wet/dry etching) and additive (oxidation, CVD, PVD, etc.) processes;
- polymer microtechnologies;
- assembling approaches;
- advanced lithographic techniques: EUV, e-beam lithography, dip-pen lithography, two-photon lithography;
- soft lithography: hot-embossing, nanoimprint lithography, replica molding;
- equipment and working environment.

Metodi didattici
Lectures (8 hours) on theoretical topics needed for the analysis and synthesis of micromechatronic systems, with particular reference to the bioengineering field.
Lectures (28 hours) illustrating the main microfabrication technologies, with reference to biomedical examples.
Innovative learning (12 hours): Classroom exercises illustrating the use of theoretical and technological tools by reading and commenting interactively cutting-edge scientific literature; Cleanroom training activities.

Modalità di verifica dell'apprendimento
Knowledge assessment methods and criteria:
Knowledge and capability to apply knowledge will be assessed by means of an oral test (approx. 30 min).

The test aims at assessing:
1. Knowledge and understanding of the subject;
2. Capability to apply knowledge and understanding to real world problems in the field of nanofabrication for biology and medicine;
3. Communication skills, such as the capability to address both specialistic and non-specialistic audience with unambiguous explanations;
4. Ability to autonomously perform evaluations in the use of microfabrication to medical and biological problems;
5. Ability to autonomously extend knowledge by accessing the literature.

In particular, communication and learning skills are evaluated by asking the student at least two questions on theoretical topics. Such questions are typically conceived so that their answers require the student to interlace and discuss distinct topics presented at different moments in the course.
Knowledge application capability and critical/analytical skills are evaluated by administering a project exercise that requires the identification of a suitable microfabrication process for the production of a given device, taking into account the constraints imposed by the technologies presented in the course.

In order to pass the exam, the student must score at least 18 out of 30. At the discretion of the exam committee, the "laude" is assigned to students who not only have adequately studied all the topics of the course but also demonstrate an uncommon ability to apply the acquired knowledge, to properly analyze and solve design problems different from those illustrated in the course. Conversely, the exam is not passed if the student has not adequately studied at least one of the fundamental topics, pointed out during the course, or when the student lacks basic knowledge in Physics, Chemistry or Mathematics.

Testi di riferimento

- Handouts and selected publications available at http://elearning.unicampus.it
- M.Madou, Fundamentals of Microfabrication and Nanotechnology, 3rd Ed., CRC Press, 2011.
- B.Bhushan, Springer Handbook of Nanotechnology, 4th Ed., Springer, 2017.

Altre informazioni

Knowledge and Understanding:
Knowledge of the basic microfabrication methods
Knowledge of the fundamental techniques to realize microfluidic chips and organ-on-chip devices

Applying knowledge and understanding:
Ability to design and realize microdevices.

Making judgements:
Ability to develop approaches for evaluating design requirements and fabrication strategies.

Communication skills:
Ability to describe microfabrication procedures using a suitable language.

Learning skills:
Ability to autonomously broaden the knowledge on the topic by reading and understanding scientific literature.

L'attività didattica è offerta in:

Facoltà Dipartimentale di Ingegneria

Tipo corso	Corso di studio (Ordinamento)	Percorso	Crediti	S.S.D.
Corso di Laurea Magistrale	Master of Science in Biomedical Engineering (2019)	Nanotechnology and Bioartificial Systems	6	ING-IND/34

Stampa del 07/05/2025

Bionic Systems and Neuroengineering [2201230]

Offerta didattica a.a. 2024/2025

Docenti: LOREDANA ZOLLO

Periodo: Secondo Ciclo Semestrale

Obiettivi formativi

The course objective is to introduce the student to the main themes of neuroengineering and bionics, with specific attention to upper and lower limb prosthetics and natural-artificial interfacing systems.
The course provides the student with:
- Theoretical knowledge on principles, modelling and development of sensory-motor prostheses and on the main interfacing methods with the Central and the Peripheral Nervous System;
- Abilities synthesized as follows:
(i) Practical Basis for analysis and development of upper and lower limb myoelectric prostheses with sensory feedback;
(ii) Competences on tools and instruments for simulation and computational modeling of interfaces between the prosthesis and the nervous system.

Prerequisiti

No prerequisites are required

Contenuti del corso

- Limb Prosthetics (8 hours):
o Introduction to sensory-motor prosthesis. Upper and lower limb prostheses: taxonomy and functioning principles. Artificial touch for neuroprosthesis.

- Natural-artificial interfacing systems (8 hours)
o Central Nervous System and Peripheral Nervous System interfaces: taxonomy and functioning principles; Invasive and non-invasive interfaces for user intention decoding and for sensory stimulation. Prosthesis with neural interface and bidirectional control (UCBM experiences).

- Fundamentals of Neurophysiology (8 hours):
o Muscles modelling; Nervous system cells; ion channels; membrane potential; action potential; sensory encoding; touch.

- Myoelectric control (8 hours):
o Direct control; Pattern Recognition techniques; Examples of application on upper limb prosthesis

- Sensory Feedback (16 hours):
o Invasive and non-invasive electrical stimulation techniques; Encoding algorithms for sensory feedback restoring; Nerve-electrode interaction modelling through FEM analysis (Comsol Multiphysics) and mathematical modelling (Neuron).

Metodi didattici

Lectures on the topics of the course and case studies on their application to specific problems (32 hours).

Seminars (4 hours) held by experts in the field of upper and lower limb prosthetics.

Practical activities consisting of exercises and laboratory (12 hours), for teaching the use of software tools and the implementation of encoding algorithms for sensory feedback restoring and nerve-electrode interaction modelling.

Modalità di verifica dell'apprendimento

Knowledge acquired during the course is evaluated through an oral exam.

The assessment of acquired knowledge will be verified by a commission composed of course of the teachers, who will verify the knowledge of the theoretical aspects of the course, and the course assistants, who will verify students' capabilities to apply the theoretical knowledge to a practical problem.

The oral exam has to ascertain:
1. Knowledge and comprehension capabilities related to the course topics;
2. Capability to apply knowledge and acquired competences to find out solutions (also original) to problems related to bionic and human-machine interface;
3. Capability to apply methods and instruments presented during the course to solve problems related to modelling, simulation and analysis of natural-artificial interactions;
4. Communication abilities in the formal description of the course topics, clearly speaking and describing without ambiguity conclusions, and underlying knowledge and considerations, to specialist and non-specialist interlocutors in national and international contests;
5. Judging autonomy to choose solutions to problems of analysis and development of bidirectional prostheses and capabilities to manage activities or technical/professional projects in their field of study and of taking decisions with the related responsibilities;
6. Capability to engage autonomously in permanent learning.

The oral exam has a maximum duration of 45 minutes.

Criteria for measuring learning and defining the final grade:

During the oral exam the commission will ask three questions to ascertain the student's knowledge about the course topics. The three questions are evaluated with equal weight (11 points for each question)
The exam is passed if the candidate reaches the minimum score of 18/30

The final evaluation is the sum of the evaluations on the three questions. Honors will be given in case of full marks for all the examinations and a final score higher than 30.

Testi di riferimento
- Lecture notes provided by the teacher;
- E.R. Kandel, J.H. Schwartz, T.M. Jessel, Principles of Neurosciences;
- P. Dayan, L.F. Abbott, Theoretical Neuroscience. Computational and Mathematical Modeling of neural systems;
- Burak Guclu, Somatosensory Feedback for Neuroprosthetics, Academic Press 2021

Altre informazioni
Knowledge and understanding:
• Fundamentals of myoelectric controlled prosthesis and of the main natural-artificial invasive and non-invasive interfaces;
• Software tools for computational modelling and simulations using FEM analysis;

Applying knowledge and understanding:
• Ability to employ methods and tools for analysis, modelling and control of bionic systems;
• Ability to develop, by the means of advanced methods, natural-artificial interface systems for sensory feedback restoration, also proposing innovative solutions for single components or for the integrated system;
• Ability to use software tools to support simulations and modelling regarding prosthetics and interfaces with the central or the peripheral nervous system.

Autonomy in judging:
Students will be encouraged to develop their analytical and critical abilities through exercises on the topics explained during lectures, and practical activities of analysis, simulation and modelling.

Learning skills:
The course relies on an approach based on the active involvement of the students by promoting re-examination and in-depth analysis of competences acquired in previous studies, and the application of the learnt concepts in other specific areas.

Communication abilities and soft skills:
The course wants to promote the development of communication abilities and soft skills to work in team and in multidisciplinary settings. This goal will be pursued by soliciting pro-active involvement of the students during the lectures and carrying out practical activities requiring practical implementation of the learnt teoretical issues.

L'attività didattica è offerta in:

Facoltà Dipartimentale di Ingegneria

Tipo corso	Corso di studio (Ordinamento)	Percorso	Crediti	S.S.D.

Corso di Laurea Magistrale	Master of Science in Biomedical Engineering (2019)	Biorobotics and Ergonomics	6	ING-IND/34
Corso di Laurea Magistrale	Master of Science in Biomedical Engineering (2019)	Nanotechnology and Bioartificial Systems	6	ING-IND/34

Stampa del 07/05/2025

Biorobotics [2201220]

Offerta didattica a.a. 2024/2025

Docenti: EUGENIO GUGLIELMELLI

Periodo: Secondo Ciclo Semestrale

Obiettivi formativi
The course aims to provide to the student the following knowledge in the field of Biorobotics:
• Main definitions, taxonomies and application fields for biorobotic systems;
• Main concepts regarding the state of the art of biorobotics and design and development of biorobotic systems.

Prerequisiti
None.
Suggested prior exams: Meccatronica per i Sistemi Biomedicali, Robotica Industriale e Medica

Contenuti del corso
• Introduction to Biorobotics: reference definitions and conceptual schemes (1.0 CFU);
• Historical background and state of the art of the Biorobotics (1.0 CFU);
• Differences and similaritirs between biological and robotic systems (1.0 CFU);
• Bio-inspired robotic systems: design principles, methods and case-studies (0.5 CFU);
• Enabling technologies in biorobotics: sensors, actuators and control architecture (2.0 CFU)
• Biorobotics future perspectives (0.5 CFU).

Metodi didattici
Frontal lessons (5.5 CFU) where the teachers will introduce course arguments and show the application of the theoretical knowledge previously presented in frontal lessons.
Seminars (0.5 CFU) delivered by experts from the academic and/or industrial world.

Modalità di verifica dell'apprendimento
Knowledge assessment methods and criteria:

The exam consists of an oral test.
In the oral test, the teacher will asl three questions aiming to verify the student's knowledge about the course contents.
The three questions are scored with equal weight (11 points)
Maximum oral test duration: 45 minutes.

Criteria for measuring learning and defining the final grade:

The exam is considered passed if the candidate achieves at least 18/30.
The laude is assigned to students who have (i) correctly answered all teachers’ questions and (ii) achieved a final grade above 30/30.

Testi di riferimento
Used teaching material:

• Fumiya Lida and Auke Jan Ijspeert. "Biologically inspired robotics." Springer Handbook of Robotics. Springer, Cham, 2016. 2015-2034
• Kortenkamp, D., Simmons, R., & Brugali, D. (2016). Robotic systems architectures and programming. In Springer Handbook of Robotics (pp. 283-306). Springer, Cham
• Jean-Arcady Meyer and Agnes Guillot. “Biologically inspired robots” Springer Handbook of Robotics. Springer, Cham, 2016. 1395-1422
• Stefano Nolfi, Josh Bongard, Phil Husbands and Dario Floreano. “Evolutionary robotics” Springer Handbook of Robotics. Springer, Cham, 2016. 1395-1422
• Braitenberg, Valentino. Vehicles: Experiments in synthetic psychology. MIT press, 1986;
• Laprie, Jean-Claude. "Dependability: Basic concepts and terminology."
• Slides used by teacher during frontal lessons, papers and additional materials provided by teacher

These materials will be shared on the course page of the UCBM e-Learning platform.

Optional teaching material:

Additional scientific paper for an in-depth analysis of themes and/or case studies provided by the teacher and tutors. These materials will be shared on the course page of the UCBM e-Learning platform.

Altre informazioni

Specific learning outcomes:
Knowledge and understanding
• Theoretical and practical knowledge and skills on methods and instruments for conception, design and development of biorobotic systems;
• Theoretical knowledge and skills on the use of technological tools for modeling biological systems and for simulating, designing, implementing and delivering to a variety of applications bioinspired robotic systems.
Ability to apply knowledge and understanding
• Know how to use operating tools and advanced methodologies for conceiving, designing and developing bioinspired robotic systems.
Making judgements
The students will be encouraged to develop their analytical and critical skills by proposing: i) examples and applications regarding the theme introduced during frontal lessons and ii) case studies of bioinspired systems used for the validation of scientific hypotheses on natural species or for solving practical problems from an engineering perspective.

Learning skills
The students will be actively involved during the frontal lessons and exercise classes. Practical examples in the field of Biorobotics will be introduced to motivate the in-depth analysis of topic discussed during frontal lessons. During exercise classes examples will be presented as applications to specific problems.
Communication abilities
Particular attention will be provided to the development of communication abilities by actively involving the student during the frontal lessons and exercise classes.

L'attività didattica è offerta in:

Facoltà Dipartimentale di Ingegneria

Tipo corso	Corso di studio (Ordinamento)	Percorso	Crediti	S.S.D.
Corso di Laurea Magistrale	Master of Science in Biomedical Engineering (2019)	Biorobotics and Ergonomics	6	ING-IND/34

Stampa del 07/05/2025

Acceptance tests and performance periodical checks of medical devices [2201215]

Offerta didattica a.a. 2024/2025

Docenti: CARLO MASSARONI

Periodo: Primo Ciclo Semestrale

Obiettivi formativi
This course aims at giving to the students the fundamentals and the methodological approach for the realization of the on-site testing and performance checks of electromedical equipment. Classes and laboratories will focus on providing the main theoretical, technological and experimental knowledge related to acceptance tests and to safety and/or performance periodical checks of medical devices, risk assessment and the presentation and interpretation of the results

Prerequisiti
None

Contenuti del corso
Part I - Basic introductory elements
Definition of electromedical equipment.
Reference legislation and content analysis. National and international data.
Medical equipment maintenance policy. Types of maintenance and maintenance strategies.
Risk analysis.
Rationalization of medical equipment purchases.
Feasibility analysis.
Methodologies for the calculation of the return of investment.
Procedures of public evidence: the technical specifications.

Part II - Acceptance testing and performance checks
The testing of a contract: technical and administrative aspects.
European Directive 93/42 on medical devices.
Test classifications.
Acceptance testing of biomedical equipment. The testing certificate. Drafting of the test report.
Identification of the critical issues of an equipment through a systemic approach: systems, equipment, patient and user.
Risk Analysis and Health technology assessment.

Part III - The fundamentals of experimental verification
The experimental method and the design of the experiment.
Presentation of experimental data.
General rules, uncertainty of measurement, significant figures, rounding.
International System of Units.
Estimation of measurement uncertainty: general guidelines, estimation of type B and type A uncertainty. Estimation of Measurement Position and dispersion indices. Gaussian and Student distribution.
Uncertainty propagation and comparison between experimental data.

Part IV - Medical equipment safety
Basic safety of medical equipment.
Standard CEI 62-5, CEI 62-51, CEI 62-122, and CEI 62-128.
Medical equipment or medical system parts that contact the patient.
Protection against electrical hazards from medical equipment.
Fundamental rules of protection against electric shock.

Part V - Testing and verification of critical equipment
Particular requirements and essential performance of for the safety of lung ventilators - Critical care ventilators, anaesthetic systems.
Standards CEI 62-141 and ISO 5367.
High frequency electrosurgery devices. Standard CEI 62-11.
Particular requirements for the safety of cardiac defibrillators. Standard CEI 62-13.

Metodi didattici
Lectures and lab experiences.
Lecture hours: 38
Lab experiences hours: 10

The course includes three practical lab experiences. The first one aims to learn the use of software and algorithms for the correct representation of experimental data obtained in contexts of electrical verifications and/or equipment testing. In this case students are required to use MATLAB/Excel. The other two practical experiences are dedicated to the electrical verification and testing of one/two electromedical devices present at the Policlinico Universitario Campus Bio-Medico di Roma. To carry out these exercises, students are divided into groups (maximum 6 members). At the end of the practical exercises, it is required the drawing up of a report, then evaluated during the final exam.

Modalità di verifica dell'apprendimento
Learning will be assessed through a presentation of the test report and an oral test.
The presentation is intended to establish in addition to language skills in report writing and verbal communication:
- The capability to apply concepts related to electrical safety, performance and testing regulations to practical cases of acceptance and verification of an electromedical device
- The ability to apply statistical and analytical methods to present and interpret data recorded during an acceptance test or performance periodical check of a medical device.
- The ability to independently evaluate and discuss data taken during the verification of an electromedical device to determine the acceptability of the device

In the presentation, team members will be asked to present the basic steps and results obtained during a test of an electromedical device. Each presentation will last a maximum of 15 minutes.
The oral interview is used to assess the theoretical basis and aims to ascertain:
• The knowledge of the legislation and reference tests related to the testing of an electromedical device and the maintenance of its performance;
• The knowledge of the standards related to electrical safety, testing and classification of electromedical equipment;
• The knowledge of the main techniques for presenting and interpreting experimental data.
The test will consist of at least 2 questions of increasing complexity and the ability to communicate knowledge clearly and unambiguously will be assessed positively. The duration of the oral test will be approximately 30 minutes.

Testi di riferimento
Learning support materials
Handouts and teaching materials provided by the teacher through the e-learning platform: http://elearning.unicampus.it.
Pieces of CEI Standards regarding electromedical equipment, safety requirements and performances that some electromedical equipment or medical device must comply with.
F.P. Branca, “Fondamenti di Ingegneria Clinica” Vol. I e II, Springer, Milano 2008.
A. Ferraioli, “Manuale di ingegneria biomedicale”, Dario Flaccovio Editore s.r.l., 2020

Altre informazioni
• Knowledge of the legislation and reference tests related to the testing of an electromedical device and the maintenance of its performance;
• Knowledge of the standards related to electrical safety, testing and classification of electromedical equipment;
• Knowledge of the main techniques for presenting and interpreting experimental data;
• Capability to apply concepts related to electrical safety, performance and testing regulations to practical cases of acceptance and verification of an electromedical device
• Ability to apply statistical and analytical methods to present and interpret data recorded during an acceptance test or performance periodical check of a medical device.
• Capability to communicate and clearly explain, using an appropriate technical/scientific terminology, the main concepts taught during the lectures and seminars.

L'attività didattica è offerta in:

Facoltà Dipartimentale di Ingegneria

Tipo corso	Corso di studio (Ordinamento)	Percorso	Crediti	S.S.D.
Corso di Laurea Magistrale	Master of Science in Biomedical Engineering (2019)	Clinical Engineering	6	ING-IND/12

Cyber Security for Operational Technologies [2201233]

Offerta didattica a.a. 2024/2025

Docenti: LUCA FARAMONDI

Periodo: Secondo Ciclo Semestrale

Obiettivi formativi

The goal of the course is to provide students of Chemical Engineering for Sustainable Development the tools to study the dynamic behavior of industrial processes and to design the control systems of both single equipment and complete industrial plants.
Starting from the knowledge of mathematical and physical basic concepts such as Laplacian operators, energy and material balances, the concept of stability of open and closed loops, the student will apply these concepts to the dynamic study of the industrial equipment and to the analysis of feed-back and feed-forward control cycles.
After completing the course, the student will have all elements to analyze and design an industrial controller.

KNOWLEDGE AND UNDERSTANDING ABILITY
The course aims to provide knowledge and understanding ability on dynamic modeling of industrial processes and on the development of process control systems.

APPLICATION ABILITY
At the end of the course the student will be able to:
- formulate dynamic models of industrial processes;
- define control strategies;
- set the tuning of feedback control parameters;
- develop process schemes.

AUTONOMY OF JUDGEMENT
The student will be encouraged to develop a critical approach on the processing and understanding of concepts through questions on topics which may prove confusing. Students will be encouraged to independently verify the plausibility of the proposed solutions of their problems.

COMMUNICATION SKILLS
The student will learn how to present the arguments clearly and effectively. It will organize the presentation in sequential order starting from the basic knowledge required to develop the argument in a comprehensive manner.

LEARNING SKILLS
The student will develop an increasing capacity to learn through a method of study that makes productive the attendance at lectures and exercises, through active participation to them.

Prerequisiti

none

Contenuti del corso

Module A
Dynamics of an industrial process: application of models of the first and second order, FOPTD and SOPTD.
Dynamic model of a distillation column: Matlab modeling.
Empirical models of industrial equipment.
Valves and actuators.
Feedback control loops: control algorithms and tuning of the parameters, ratio control, applicative examples.
Feedforward control loops: the concept of predictive model, control algorithms.
Control cycles modeling in Simulink environment.
Batch control systems.
Process schemes: graphics criteria and applications.
P&ID schemes

Module B
Process control concept and objectives. General information on control systems.
Dynamic systems - Dynamic response, Laplace transforms, Transfer functions, Bode diagram, State space and

Linearization.
Process feedback techniques with output feedback and state feedback.
The digital twin and elements of fault detection
Supervision, monitoring and control systems: architecture and operating principles of the Distributed Control System (DCS), Programmable Logic Controller (PLC), Supervisory Control And Data Acquisition (SCADA); notes on industrial protocols.
Elements of Cyber security for Operational Technology.
Laboratory activities

Metodi didattici
Lectures presenting the topics of the course, exercises to show their application to specific problems. Labs activities are planned.

Modalità di verifica dell'apprendimento
Knowledge assessment methods and criteria:
The knowledge acquired will be verified by a written exam and an oral test.
During the written exam, the knowledge and skills related to the study of dynamic systems and the design of industrial control systems are verified by the execution of two exercises related to the Module A.
The oral exam consists of two questions on the course program, and the discussion of a thesis related to the Module B. The oral test lasts about 20 minutes.
Criteria for measuring learning and defining the final grade:
The written exam evaluation is expressed as a grade of out of 30. The written exam is deemed to be passed successfully if the final grade is equal to or higher than 18/30.
The evaluation of the oral exam is expressed as a grade of out of 30. The oral test is deemed to be passed successfully if the final grade is equal to or higher than 18/30.
The final score is the average of the two votes.

Testi di riferimento
D.E. Seborg, T.F. Edgar, D.A. Mellichamp, “Process Dynamics and Control”, Wiley Ed.

L'attività didattica è offerta in:

Facoltà Dipartimentale di Ingegneria

Tipo corso	Corso di studio (Ordinamento)	Percorso	Crediti	S.S.D.
Corso di Laurea Magistrale	Master of Science in Biomedical Engineering (2019)	Common	6	ING-INF/04

Stampa del 07/05/2025

Dynamics of Complex Systems [2201124]

Offerta didattica a.a. 2024/2025

Docenti: SIMONETTA FILIPPI

Periodo: Primo Ciclo Semestrale

Obiettivi formativi
The course aims to provide students with the knowledge and understanding of the theoretical and computational physical-mathematical modeling criteria of multi-physical and multi-scale chemical-physical and biological phenomena with particular reference to the organs and functions of the human body. Furthermore, the course aims to introduce the student to the interdisciplinary approach to complex problems of Engineering and Biosciences.

Prerequisiti
No specific propaedeutic course. Recommended notions of Calculus I and II. Ordinary differential equations. Partial differential equations. Mechanics and Thermodynamics. Electromagnetism. English language.

Contenuti del corso
Chaos, Fractals, and Dynamics of Complex Systems (2h):
- Introduction.
- Nonlinearity in Nature.

Flux on the line (2h):
- Geometric interpretation, stability.
- Bifurcations.
- Laser.

Oscillators (2h):
- Uniform and non-uniform oscillators.
- Pendulum.
- Synchronization.

Linear and Non-Linear Systems (2h):
- Definitions.
- Classification.
- Phase space.
- Linearization.

Limit Cycle (2h):
- Poincaré-Bendixon.
- Weakly oscillators.
- Van Der Pol.
- Hopft Bifurcations.

The Lorenz model and the deterministic Chaos (6h):
- Fluidodynamics and the Lorenz systems.
- Application to the water wheel.

Uni-dimensional maps (4h):
- logistic map, Lyapunov exponent.

Applications (10h):
- Turing, Zhabotinsky-Belousov.
- Cellular automata, Hodgkin-Huxley.
- Fitzhugh-Nagumo.
- Models of excitable systems.

Computational cardiology (10h):
- Cardiac tissue model.
- Thermo-electric coupling.
- Arrhythmias.

PDE theory (2h).
Numerical simulations (Comsol Multiphysics) (30h).

Metodi didattici
Lectures (60%) introducing and explaining the experimental evidence, the theoretical formulations and their proof of the concept of the Dynamics of Complex Systems.
Practical sessions (40%) in which the student is trained into the usage of dedicated software for the solution and

graphical representation of ODE and PDE.

Modalità di verifica dell'apprendimento
The knowledge and skills learned during the course will be assessed through a theoretical written test and a practical test at the end of the course.
The theoretical written test (evaluated maximum 20/30, with a duration of one hour) will consist of the written argumentation of two topics (max two pages) concerning the topics covered during the course. In the test, students will also have to apply previous notions of physics and understand a text in English. Students are expected to use the notions and concepts acquired during the course and to critically develop the study topics to evaluate their capacity for theoretical understanding, ability to learn, and autonomy of judgment. The relative discussion with the teacher of the questions will also allow the evaluation of the communication skills acquired by the student.
The practical test (evaluated at most 10/30 and engaging the student for one hour) will verify the learning level of the practical skills acquired in terms of using and implementing a dynamic model within a multi-physics simulation software (finite elements method) and creating a report with relative post-processing.

The exam result is graded up to 30 points. The maximum grade, 30/30 e lode, will be assigned to students who produce an excellent exam and can answer the questions considered during the course at best.

Testi di riferimento
Reference Textbooks:
- Strogatz, S. Nonlinear Dynamics and Chaos With applications to physics, biology, chemistry, and engineering. Perseus Books, Cambridge, Massachusetts, 1994
- Keener J., Sneyd J. Mathematical Physiology. Springer, 1998

Lecture notes from the lecturer.
Additional references:
N.F. Britton, Essential Mathematical Biology. Springer, 2003.

Altre informazioni
Knowledge and understanding. Students will acquire the basic notions related to the physical-mathematical modeling of complex phenomena. Students will develop skills in critical analysis of models and simulations of existing biological systems and their use for solving specific problems in Biomedical Engineering.
Applied knowledge and understanding. Students will acquire the necessary skills in the main methods and tools for theoretical and numerical modeling of non-linear and complex systems. A practical learning path of methods and tools for modeling biological and physiological systems is foreseen. Thanks to innovative teaching methods, such as flipped classrooms and advanced seminars, students practice logical reasoning skills that lead to constructing a specific dynamic model.
Autonomy of judgment. Students will be stimulated to develop their analytical and critical skills, acquiring the skills necessary for evaluating the type of dynamic system modeling useful in the biomedical field.
Communication skills. Downstream of the course, students will have developed communication skills, such as using a scientific vocabulary to communicate with national and international experts in biomedical practice and research.

Ability to learn. Students will be able to find information and insights using the sector's scientific literature and comparing with colleagues and teachers. They will also be able to build dynamic models of specific biological systems.

L'attività didattica è offerta in:

Facoltà Dipartimentale di Ingegneria

Tipo corso	Corso di studio (Ordinamento)	Percorso	Crediti	S.S.D.
Corso di Laurea Magistrale	Master of Science in Biomedical Engineering (2019)	Common	9	FIS/02

Stampa del 07/05/2025

Image and digital signal processing [2201140]

Offerta didattica a.a. 2024/2025

Docenti: LEANDRO PECCHIA

Periodo: Primo Ciclo Semestrale

Syllabus non pubblicato dal Docente.

L'attività didattica è offerta in:

Facoltà Dipartimentale di Ingegneria

Tipo corso	Corso di studio (Ordinamento)	Percorso	Crediti	S.S.D.
Corso di Laurea Magistrale	Master of Science in Biomedical Engineering (2019)	Common	6	ING-INF/05

Stampa del 07/05/2025

Electronics and sensors for biomedical applications [2201047]

Offerta didattica a.a. 2024/2025

Docenti: MARCO SANTONICO

Periodo: Primo Ciclo Semestrale

Obiettivi formativi

The course will provide the skills and knowledge on sensors for chemical and biological physical quantities and on their electronic interfaces in order to optimize the output signal.

Prerequisiti

Electronics basic knowledges

Contenuti del corso

Part I (14 hours)
Fundamental figures characterizing the response, sensitivity, noise, resolution, selectivity and specificity.
Signals transiting through the sensors.
Equivalent circuits. Transducers.
Sensor Technology: microsensors and nanosensors. Recovery techniques of the signal when the signal / noise ratio is less than one. Interfaces.
Network theorems applied to simple interfaces between sensors and processing systems.

Part II (24 hours)
Generalized divider and their behavior in the time and frequency domain.
Use of the operational amplifier in the field of filters and differential amplification.
Procedures for the optimization of the interfaces. Picoammeter. Electrometer. Opamp based circuit configurations.
Series and parallel regulators. Current and voltage source.
Physical and Chemical sensors. Oscillators basic theory.

Laboratory experiences to acquire experimental skills in design and processing electronics interface (10 hours).

Metodi didattici

Lectures (38 hours) presenting the topics of the course and during which specific exercises will be carried out to show the application of theoretical subjects to specific problems.
The student will develop a practical project (10 hours) using the knowledge acquired during the course. The project, developed by small groups of 3-5 students, will consist of the study and realization of an electronic device for the detection of chemical or physical quantities.

Modalità di verifica dell'apprendimento

Knowledge assessment methods and criteria:

Oral examination.
The student will have to demonstrate adequate knowledge and understanding of the sensors' theoretical and practical aspects and electronic interfacing. The student will have to be able to apply the acquired knowledge in particular applicative contexts inherent to the biomedical field. The student will present the project developed during the course to evaluate her/his communication and judgment skills in a specific application context during the oral exam. Furthermore, the design skills acquired during the course will be verified by asking the student to size, adapt or combine circuit solutions on specific requests proposed during the examination.

Criteria for measuring learning and defining the final grade:

10 points of the final grade will be given on the basis of the project evaluation. The other 21 points will be assigned on the basis of student's response to questions proposed during the oral exam after the presentation of the project. Honors will be awarded to the students who have obtained a final grade higher than 30.

Testi di riferimento

Material provided by the teacher

Arnaldo D'Amico,Corrado Di Natale, Introduzione ai sensori, Ed. Aracne, 2008

Paul Horowitz/Winfield Hill-‘L’arte dell’elettronica’-Zanichelli
Sergio Franco – ‘Design with Operational Amplifiers and Analog Integrated Circuits’ – McGraw Hill Higher Education; 3rd edition.
Sedra/Smith- ‘Circuiti per la microelettronica’-Edises

Altre informazioni

Knowledge and understanding
The course will provide to the student the knowledge of the fundamentals, internationally recognized, that concern the sensors for chemical, biological and physical quantities for a deep understanding of the working principle.

Applying knowledge and understanding
The students will know the theoretical and scientific aspects of the discipline covered in the course and they will be able to identify and resolve complex problem with original design.

L'attività didattica è offerta in:

Facoltà Dipartimentale di Ingegneria

Tipo corso	Corso di studio (Ordinamento)	Percorso	Crediti	S.S.D.
Corso di Laurea Magistrale	Master of Science in Biomedical Engineering (2019)	e-Health Systems	6	ING-INF/01

Stampa del 07/05/2025

Electrical and Mechanical System of a Health care structure [2201216]

Offerta didattica a.a. 2024/2025

Docenti: FABIO FIAMINGO

Periodo: Secondo Ciclo Semestrale

Syllabus non pubblicato dal Docente.

L'attività didattica è offerta in:

Facoltà Dipartimentale di Ingegneria

Tipo corso	Corso di studio (Ordinamento)	Percorso	Crediti	S.S.D.
Corso di Laurea Magistrale	Master of Science in Biomedical Engineering (2019)	Clinical Engineering	6	ING-IND/10, ING-IND/33

Stampa del 07/05/2025

Informatics for Embedded Systems [2201228]

Offerta didattica a.a. 2024/2025

Docenti: LUCA VOLLERO

Periodo: Primo Ciclo Semestrale

Obiettivi formativi

The course aims to provide advanced tools for understanding the structure of microcontrollers, their low-level programming, and the design and implementation of IoT edge system.

Prerequisiti

-

Contenuti del corso

By Prof. Vollero:
- The Architecture of Computing Systems.
- Central memory and addressing modes.
- The Input/Output System.
- The system of interrupts.
- CPU-peripheral synchronization: scheduled I/O, I/O with interrupts. DMA. I/O processors.
- Machine language and introduction to assembly language.
- Subprogram management in machine language: problem of linking and parameter passing.
- Use of the stack for linking and activation record allocation.

By Eng. Sabatini
- Firmware design on embedded systems.
- Schedulers on embedded systems and RTOS.
- Sensor interfacing
- Parallel task handling on embedded systems
- Data communication

Metodi didattici

The course consists of lectures (36 hours), in which theoretical topics are covered, and exercises (12 hours) in which practical problems related to the design and development of IoT edge system components are solved together with the student.

Modalità di verifica dell'apprendimento

Learning is assessed by means of a homework assessment and an oral test.

The homework aims to ascertain.
1. knowledge and understanding skills applied to the analysis of IoT edge system design problems.
2. autonomy of judgment in evaluating and choosing solutions to IoT edge system design problems.

The oral test aims to ascertain.
1. knowledge and understanding skills of the course topics.
2. communication skills in formal description of IoT edge system design topics.
3. ability to apply the acquired knowledge and skills in formulating original solutions to IoT edge system design problems.

The final grade, in thirtieths, is obtained by averaging (50% on points 1 and 2, 50% on points 3 and 4) the results of the homework and oral test expressed in thirtieths.

The examination is passed if the candidate achieves at least 18/30.

The award of praise is based on point 5 and requires, as a necessary condition, the achievement of a grade of 30/30.

Testi di riferimento
• David A. Patterson, John L. Hennessy, Struttura e progetto dei calcolatori, progettare con RISC-V, Zanichelli
• C. Hamacher, Z. Vranesic, S. Zaky, Introduzione all''architettura dei calcolatori 3/ed, McGraw-Hill
• Tannenbaum, T. Austin. Structured Computer Organization (6th Edition). Prentice Hall. Morgan Kaufmann
• Course notes

Altre informazioni
Knowledge and understanding skills:
- Knowledge of main models of programmable computing system, programming and I/O interfacing models, networking protocols, and IoT edge system design.
- Ability to understand the operation of programmable computing systems, control, interfacing and networking software.

Applied knowledge and understanding skills:
- Knowledge of microcontroller system management software analysis and design techniques.
- Ability to design software to manage and interface a microcontroller system.

Autonomy of judgment:
- Ability to independently and critically apply learned design techniques to solving IoT edge system design problems.

Communication skills:
- Ability to coherently and clearly describe models and systems learned in the course.
- Ability to consistently and clearly formalize and describe problems and solutions related to IoT edge systems.

Ability to learn:
- Ability to extend the body of knowledge acquired in the course independently.

L'attività didattica è offerta in:

Facoltà Dipartimentale di Ingegneria

Tipo corso	Corso di studio (Ordinamento)	Percorso	Crediti	S.S.D.
Corso di Laurea Magistrale	Master of Science in Biomedical Engineering (2019)	e-Health Systems	6	ING-INF/05

Stampa del 07/05/2025

Artificial Organs Engineering [2201045]

Offerta didattica a.a. 2024/2025

Docenti: VINCENZO PIEMONTE

Periodo: Secondo Ciclo Semestrale

Obiettivi formativi

The purpose of the course is to provide students with the knowledge of the operating principles and calculation criteria of artificial and bioartificial organs. The course aims to provide knowledge and understanding on the principles of design of artificial organs The student will be stimulated to develop a critical approach on the elaboration and understanding of concepts through questions on the topics that are unclear. Students will be encouraged to independently verify the plausibility of the solutions to the problems proposed to them.

Prerequisiti

none

Contenuti del corso

Introduction to the engineering of artificial organs (2h)
Transfer of matter in artificial organs. Diffusion and convection. Diffusion and reaction. Dimensionless analysis (10h of which 5h for exercises).
Enzymatic kinetics, free and immobilized enzymes (5h of which 1.5h for exercises).
Cell kinetics (3h). Cellular bioreactors (3h of which 1.5h for exercises).
The elements of artificial organs: membranes, adsorption columns, criteria for the calculation of the main equipment (5h of which 2h for exercises).
The artificial kidney: dialysis, properties of membranes, clearance, pharmacokinetic models patient-device; (6h of which 2h for exercises),
The artificial and bioartificial liver: blood detoxification, adsorption; synthesis functions and bioreactors (6h of which 2h for exercises).
Artificial lung: oxygenators, transport and exchange problems (4h).
Artificial Gastro-intestinal system for bioavailability of drugs (2h)
Artificial Pancreas (2h)

Metodi didattici

The lessons will take place through frontal teaching aimed at providing the elements for the analysis and design of processes and through group exercises to develop the skills to work in a team and deal with the resolution of real problems.

Modalità di verifica dell'apprendimento

The knowledge and skills relating to the engineering of artificial organs are verified through an oral test, based on 2 different topics, lasting a total of about 50 '. The first question will focus on basic topics and will aim at evaluating application and judgment skills, while the second one will be dedicated to more design aspects of the engineering of artificial organs, with the aim of evaluating learning and communication skills.

The grade obtained is expressed out of thirty and the exam will be passed only if a grade greater than or equal to 18/30 is achieved. The two questions will contribute with equal weight to the composition of the final grade. The candidate will be able to aspire to honors, answering the two questions perfectly and demonstrating a remarkable ability to rework the course contents. The grade obtained will be recorded in the student booklet and in an electronic report.

Testi di riferimento

Lecture notes
Annesini M.C., Marrelli L., Piemonte V., Turchetti L., Artificial Organ Engineering, Springer, 2017, ISBN 978-1-4471-6442-5, ISBN 978-1-4471-6443-2.

Altre informazioni

At the end of the course, the student is able to use advanced knowledge on the design of bioreactors and on the analysis, optimization and innovation of industrial biotechnological processes. The student will be stimulated to develop a critical approach on the elaboration and understanding of concepts through questions on the topics that were unclear. Students will be encouraged to independently verify the plausibility of the solutions to the problems proposed to them. The student will have to learn how to present the arguments in a clear and effective way. You will have to organize the exhibition in a consequential way starting from the basic knowledge required to develop the topic comprehensively. The student will have to develop increasing ability to learn through a study methodology that make attendance to lessons and exercises productive, through active participation in them.

L'attività didattica è offerta in:

Facoltà Dipartimentale di Ingegneria

Tipo corso	Corso di studio (Ordinamento)	Percorso	Crediti	S.S.D.
Corso di Laurea Magistrale	Master of Science in Biomedical Engineering (2019)	Common	6	ING-IND/24

Stampa del 07/05/2025

Ingegneria Tissutale [2201241]

Offerta didattica a.a. 2024/2025

Docenti: ALBERTO RAINER

Periodo: Secondo Ciclo Semestrale

Obiettivi formativi
Aim of the course is to provide students with the salient theoretical and practical aspects of tissue engineering, a discipline which aims to engineer tissue analogues by combining cells and biomaterial scaffolds to regenerate tissues and organs.

Prerequisiti
Basic knowledge in chemistry and materials science is recommended.

Contenuti del corso
Part I (12h): Introduction to tissue engineering; mass transport within biological tissues; generalities on 2D and 3D cell cultures; cell-cell and cell-extracellular matrix interaction; cell adhesion and migration.
Part II (8h): the scaffold; biomaterials for tissue engineering; growth factors and stem cells in tissue engineering.
Part III (8h): applications: bone, cartilage, skin, blood vessels; bioreactors and microfluidic devices for tissue engineering; mechanobiology (generalities).
Part IV (20h): methods in tissue engineering.

Metodi didattici
The course will have a large practical section and will provide basic tissue engineering skills, integrating lectures introducing the topics of the course (16h) with laboratory activities (32h).

Modalità di verifica dell'apprendimento
Knowledge assessment methods and criteria:
Knowledge will be assessed by means of a 2-hour written test with 3 open-ended questions.
The test aims to assess:
• Knowledge and understanding of the subject
• Capacity of applying knowledge and understanding to real world problems in the field of tissue engineering
• Communication skills, such as the capacity to provide both specialistic and non-specialistic audience with unambiguous explainations
• Ability to autonomously perform evaluations in the application of tissue engineering solutions.
• Ability to autonomously extend knowledge by accessing the literature

Criteria for measuring learning and defining the final grade:
To get a pass, students should demonstrate sufficient knowledges of the course contents and be able to report on the lab activities. Higher marks (above 27 out of 30) will be given to those students who are able to correlate theoretical knowledge with laboratory activities. Honors (lode) will be given to those students who obtain 30 out of 30 and show excellent presentation skills, using graphs and schemes.

Testi di riferimento
Handouts and selected publications available at http://elearning.unicampus.it
The following books are suggested for in-depth reading:
• Current protocols in molecular biology. Wiley NY
• Bruce Alberts, Molecular Biology of the cell, Garland publishing
• Kate Wilson & John Walker, Biochimica e biologia molecolare: principi e tecniche. Cortina Ed.
• Benjamin Lewin, Il gene, Zanichelli
• Robert A. Brown, Extreme Tissue Engineering: Concepts and Strategies for Tissue Fabrication, Wiley-Blackwell

Altre informazioni
Knowledge and understanding
• Knowledge of the principles of tissue engineering
• Knowledge of the most relevant physics-chemical characterization techniques used in tissue engineering

Applying knowledge and understanding
• Ability to design tissue engineered constructs

Making judgements
• Ability to autonomously perform requirement analysis and design of tissue engineering products

Communication skills
• Ability to communicate with professionals in the field of tissue engineering using a technical vocabulary

Learning skills
• Ability to autonomously extend knowledge by accessing the literature.

L'attività didattica è offerta in:

Facoltà Dipartimentale di Ingegneria

Tipo corso	Corso di studio (Ordinamento)	Percorso	Crediti	S.S.D.
Corso di Laurea Magistrale	Master of Science in Biomedical Engineering (2019)	Common	6	ING-IND/34

Stampa del 07/05/2025

General English [22011C1]

Offerta didattica a.a. 2024/2025

Docenti: ROBERTA ARONICA

Periodo: Primo Ciclo Semestrale

Obiettivi formativi
The course is aimed at consolidating the B2 CEFR level and embarking upon level C1 CEFR. The teaching activities are taught by native speakers who collaborate with the University Language Centre.

Prerequisiti
Students with language certifications – issued no longer than three years previously by one of the following Exam Certifiers: Cambridge Assessment English; LinguaSkill; City and Guilds, Pitman; Edexcel / Pearson Ltd; IELTS; TCL Trinity College London; TOEFL ET – of level C1 or higher can obtain exemption by submitting an application to the attention of the University Language Center (cla@unicampus.it).

Contenuti del corso
In the one semester, curricular course of 3 credits, English language logical-grammatical structures and vocabulary are studied in depth in order to consolidate level B2 CEFR and to embark level C1 CEFR.

Metodi didattici
The course is delivered through lectures and classroom exercises.

Modalità di verifica dell'apprendimento
Final exam.
Learning assessment is conducted via a written test consisting of grammar exercises, text comprehension, writing and listening.

Lexical and grammatical knowledge and skills related to comprehension and written production are evaluated through a written test and a listening test with a respective open-ended comprehension questions at course level. Communication skills (speaking) are assessed by the teacher during the course through interactive activities. The test is evaluated on a pass or fail basis. To be awarded a pass grade, the student must obtain a total score equal to or greater than 60%.

Testi di riferimento
The teacher will provide the teaching material during the course.

Altre informazioni
Each student is required to take a placement test to identify their initial level of knowledge of the English language.

Ability to apply knowledge and understanding
At the end of the course, the student should be able to:
– converse, read and write passages in English, answer text comprehension questions;
– produce a written text on a general topic.

Independent judgement making
The student will be encouraged to develop a critical approach in their comprehension capabilities by listening to English audios and in written production through teaching methods gradually introduced during the course. Students will be urged to independently self-correct their own papers while verifying the level of understanding of other texts analyzed during the frontal lessons.

Communication skills
The student must be able to communicate clearly and grammatically correctly.

Ability to learn
The student must demonstrate active participation by interacting in English with the teacher and the class.

L'attività didattica è offerta in:

Facoltà Dipartimentale di Ingegneria

Tipo corso	Corso di studio (Ordinamento)	Percorso	Crediti	S.S.D.
Corso di Laurea Magistrale	Master of Science in Biomedical Engineering (2019)	Common	3	L-LIN/12

Stampa del 07/05/2025

IoT Systems Design [2201219]

Offerta didattica a.a. 2024/2025

Docenti: LUCA VOLLERO, GIUSEPPE CINQUE

Periodo: Secondo Ciclo Semestrale

Obiettivi formativi
The course goal is to provide the student with the theoretical and practical knowledge needed to design and develop IoT systems.

Prerequisiti
-

Contenuti del corso
- Architecture of a Smart Object (SO)
- Interconnection of SOs
- Protocol Stack
- Internet Protocol and IoT applications
- IoT Application layer protocols
- Data analysis for IoT systems
- Security in IoT systems

Metodi didattici
The course includes frontal lessons (50%), during which the teacher presents the topics of the course, and videolectures, in which the students study autonomously specific topics that are later discussed with the teacher.

Modalità di verifica dell'apprendimento
The verification of learning is done by means of two intracourse tests, a homework and an oral test.

The homework aims to assess.
1. knowledge and understanding skills applied to formulating solutions and solving IoT system design problems.
2. independent judgment in evaluating and choosing solutions to IoT system design problems.

The oral and intracourse tests aim to assess
1. knowledge and understanding skills of the course topics.
2. communication skills in the formal description of course topics.
3. ability to apply acquired knowledge and skills in formulating original solutions to IoT system design problems.

The final grade, in thirtieths, is obtained by a weighted average (50% on points 1 and 2, 50% on points 3 and 4) of the test results expressed in thirtieths.

The examination is passed if the candidate achieves at least 18/30.

The award of praise is based on point 5 and requires, as a necessary condition, the achievement of a mark of 30/30.

Testi di riferimento
• David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton, Jerome Henry, "IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things", CISCO Press

Altre informazioni
Knowledge and understanding skills:
- Knowledge of network protocols and systems, components of an IoT architecture, their roles and interactions.
- Ability to understand the architecture of an IoT system and the operation of its components.

Applied knowledge and understanding skills:
- Working knowledge of IoT system design and implementation.
- Ability to understand and solve problems related to the development and maintenance of IoT systems.

Autonomy of judgment:
- Ability to independently apply choices inherent in IoT system design.

Communication skills:
- Ability to coherently and clearly describe the architecture and operation of an IoT system and its components.
- Ability to consistently and clearly formalize and describe problems and solutions inherent in IoT system design.

Ability to learn:
- Ability to extend the body of knowledge acquired during the course independently.

L'attività didattica è offerta in:

Facoltà Dipartimentale di Ingegneria

Tipo corso	Corso di studio (Ordinamento)	Percorso	Crediti	S.S.D.
Corso di Laurea Magistrale	Master of Science in Biomedical Engineering (2019)	e-Health Systems	6	ING-INF/05

Stampa del 07/05/2025

Final Examination [22010LF]

Offerta didattica a.a. 2024/2025

Docenti:

Periodo: Secondo Ciclo Semestrale

Syllabus non pubblicato dal Docente.

L'attività didattica è offerta in:

Facoltà Dipartimentale di Ingegneria

Tipo corso	Corso di studio (Ordinamento)	Percorso	Crediti	S.S.D.
Corso di Laurea Magistrale	Master of Science in Biomedical Engineering (2019)	Common	12	PROFIN_S

Stampa del 07/05/2025

Machine Learning & Big Data Analytics [2201235]

Offerta didattica a.a. 2024/2025

Docenti: PAOLO SODA

Periodo: Secondo Ciclo Semestrale

Obiettivi formativi
The main objective of the Machine Learning & Big Data Analytics (ML) course is to acquire the basic concepts of Machine Learning, which is the field of Computer Science that deals with the development of systems and algorithms, (deep) neural networks included, that rely on observations of data for the synthesis of new knowledge. For example, learning can take place by capturing features from examples, data structures or sensors, to analyse and to evaluate the relationships between the observed variables.

Prerequisiti
None

Contenuti del corso
- Introduction, definition of the concept of learning and pattern recognition, various definitions, methodology and process of analysis, concept of descriptor or feature (~2 hours);
- Model of data analysis process, simple example of what it means to classify based on experience, example of fish recognition, overfitting, underfitting (~2 hours);
- Types of classifiers, supervised, unsupervised, semi-supervised classification, regression (~1 hour);
- Performance evaluation methods, experimental methodologies, cross-validation, confusion matrix, matrix-derived metrics, confusion, the ROC curve (~2 hours);
- Bayes' theorem and the Bayesian classifier (~2 hours);
- Non-parametric classifier: Nearest Neighbor (NN) and its extension (kNN), reliability of kNN decisions, computational considerations (~1 hour);
- Support Vector Machine (SVM): learning algorithm, kernel types, the XOR problem (~1 hour);
decision reliability;
- Decision trees (~2 hours);
- Classification methods based on binary decomposition of multiclass problems (~2 hours);
- Multi-Expert Systems: bagging and boosting, AdaBoost; random forest (~2 hours);
- Feature selection and PCA (~2 hours);
- Unsupervised learning, clustering (~3 hours);
- Methods for regression (linear, logistic, kNN, trees, SVR) (~2 hours);
- Introduction to neural networks and deep learning, neuron model, transfer functions, perceptron, LMS, stochastic downward gradient, MLP introduction, the saturation problem, Error-Backpropagation, cross-entropy, Softmax, ReLU, Techniques to combat overfitting (e.g. L1 and L2 regularization, dropout), the problem of evanescent or explosive gradient ((~3 hours);
- Deep learning: Convolutional networks, Error-Backpropagation adaptation (~2 hours);
- Deep learning: autoencoders (~2 (~9 hours););
- Deep learning: U-Net and YOLO Net (~2 hours);
- Deep learning: introduction to generative models (~2 hours);
- Methods for the analysis of large amounts of data (~2 hours);
- Laboratory: crash course in Python and PyTorch (~3 hours);
- Laboratory: use of Matlab, Python and PyTorch for applications presented in the course (~9 hours);

Metodi didattici
The teaching is based on lectures and computer-based exercises, using open-source or proprietary packages. The split between lectures and computer-based exercises is 70%-30%, respectively, unless specific needs arise during the course.

Modalità di verifica dell'apprendimento
Knowledge assessment methods and criteria:
Knowledge and skills are tested by means of two tests. The first one consists in an experimental work to be carried out in small groups and to be presented in the classroom or in an oral interview. The aim of this test is to verify that the student has acquired the ability to use computational models to solve classification, clustering and regression problems, through the use of software tools available for the application of ML methods.

Students will be provided with a real dataset specifying the problem to be solved; for example, a dataset on a biomedical signal acquired with a certain method can be provided, requiring students to develop an algorithm able to predict the future value of the signal itself.
In the experimental work, the elements taken into account are those described in the specific learning outcomes, such as the logic adopted in solving the problem, the correctness of the identified procedure, the use of the software tools presented during the lectures.
The second test consists of an oral interview, which aims to verify that the student has acquired an adequate level of knowledge of the theoretical foundations of the main computational models for ML. During the oral test, the elements taken into consideration are those described in the specific learning outcomes, such as the logic followed by the student in formulating the answer to the question, the correctness of the procedure identified for the solution of the question, the use of appropriate language.
An example of a question might be: "please present the decision tree model".

Criteria for measuring learning and defining the final grade:
The final grade is determined mainly by the oral interview, which weighs in at 75%, which lasts 60 minutes maximum.
With reference to both the experimental work and oral test evaluation, each of the aforementioned elements weighs equally in the evaluation of the laboratory test, and the satisfaction of these aspects, at least 60%, is a necessary condition for achieving a grade of 18. Higher marks will be awarded to students whose tests meet all the above aspects, in increasing proportion.
In addition, the group that obtains the best results in the experimental work, in any case above a certain minimum threshold determined on the basis of the complexity of the problem, will be entitled to +1/+2 points on the final grade.
In order to obtain a mark of 30/30 or higher, the student must demonstrate that he/she has acquired an excellent knowledge of all the topics covered in the course, being able to link them in a logical and coherent manner.
Honors are obtained by demonstrating a high degree of knowledge of the topics and simulation tools, demonstrating a high degree of autonomy and judgment, and showing a high quality of exposition.

Testi di riferimento

Used teaching material
- Duda, et al. Pattern classification. John Wiley & Sons, 2012
- Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani - An Introduction to Statistical Learning with Applications in R. Springer Texts in Statistics.
- Notes and slides provided by the teacher

Suggested teaching material
- Charu C. Aggarwal - Data Mining the Textbook. Springer 2015.

Altre informazioni

Knowledge and understanding
Principles underlying supervised and unsupervised learning.
Methods and tools of machine learning and deep learning as well as big data mining. Validation methods.
Design criteria of a classification system, for supervised learning, and of clustering in unsupervised learning. Design criteria of an experimental validation procedure based on the characteristics of the available data set.
Software tools for the development of learning systems.

Applying knowledge and understanding
The student should acquire specific skills:
- Know how to appropriately interpret the main steps of algorithms for ML;
- Acquire the ability to use computational models for the solution of classical classification, clustering and regression problems;
- Be able to tackle a (simple) data analysis problem to synthesize new knowledge by implementing simple decision systems (e.g., to make decisions following the processing of a signal, image or video);
- Be able to use available software tools to apply Machine learning, Deep learning and Big Data analytics methods.

Making judgements
The student should:
- Know how to judge which are the appropriate choices to be made for solving real application cases.
- know how to judge the main characteristics of the presented computational models.
- know how to evaluate the appropriateness of an experimental procedure.

Communication skills
Students should know how to draw up, present and explain possible design solutions to real application cases. They also should know how to present the contents of the teaching with adequate technical language.

Learning skills
Students should develop the learning skills needed to undertake subsequent studies with a high degree of

autonomy. In particular, the student should:
- Acquire an adequate level of knowledge of the theoretical foundations of the main computational models for learning (e.g. Bayesian decision theory, neural networks, deep learning, linear and kernel classifiers, methods for combining classifiers, feature extraction and feature selection, etc.);
- Understand methods for the synthesis of new knowledge;
- Understand the fundamentals of methods for defining an experimental procedure and for performance evaluation;
- Understand the potential of ML for the development of medical applications, for computer vision, for big data analytics;
- Learn the use of appropriate development environments for the application of ML methods.

L'attività didattica è offerta in:

Facoltà Dipartimentale di Ingegneria

Tipo corso	Corso di studio (Ordinamento)	Percorso	Crediti	S.S.D.
Corso di Laurea Magistrale	Master of Science in Biomedical Engineering (2019)	Common	6	ING-INF/05

Stampa del 07/05/2025

Meccatronica per i Sistemi Biomedicali [2201144]

Offerta didattica a.a. 2024/2025

Docenti: FABRIZIO TAFFONI

Periodo: Ciclo Annuale Unico

Obiettivi formativi

The course aims at making the student able to: (i) critically analyze devices and biomedical systems in order to reconstruct their functional architecture and the rationale of their design; (ii) assess the state of the art related to specific technical problems and reuse it (iii) design concurrent systems integrating mechanical, electronic and information technology with an optimal allocation of functions; (iv) managing the acquisition and processing of multimodal data streams.
Alongside the aforementioned theoretical knowledge, the student will develop also basic skills in the use of software tools for: data analysis and simulation of mechatronic systems; microcontroller programming; design of PCBs.

Prerequisiti

Basic knowledge of analogue and digital electronics (i.e. passive components and logic ports). Elementary understanding of mechanism theory, transmission and actuation (components and models). Basic comprehension of system automation. Elementary programming skills (C/C++ and Matlab language).

Contenuti del corso

MODULE 1: Introduction to mechatronics; theoretical bases of mechatronic design, systems modelling (about 16 hours).
Introduction to biomechatronics; elements of systems theory: system classification, transfer function, frequency response, and Bode plot. Modelling of physical systems: modelling principles and examples. Examples of simulations of mechatronic systems.
MODULE 2: Electronics for Embedded Systems: Microcontrollers for Mechatronics and electronic design (about 25 hours).
Principles of PCB design; introduction to microcontrollers and selection criteria; overview of microcontroller peripherals; the PIC16F887A microcontroller; introduction to the development environment CCS; programming examples, laboratory exercises on CCS programming.
MODULE 3: Artificial Perception in mechatronic systems (about 24 hours).
Definition of sensor and transducer, classification of transducers and their properties; Function of sensors in mechatronic systems. Position sensors: switches, encoders, potentiometers, Hall effect sensors. Measuring the distance: triangulation, time of flight. Proximity sensors: ultrasonic and infrared sensors. Force Sensors: strain gauge force sensors / torque. Accelerometers and gyroscopes, applications in mechatronics and robotics. Magnetic Sensors. Example of artificial vestibular system. MATLAB Tutorial: data fusion algorithms for attitude estimation.
MODULE 4: Mechanics and actuation systems for biomechatronic devices, low-level control strategies; mechanical design principles and examples (about 15 hours).
Classification and operational principles of the actuation systems for biomechatronic devices. Comparative analysis and selection criteria of actuation systems. Electric motors: DC motors, brushless and stepper. Motion control: closed loop control, PID control. Power supply sources for mechatronic systems. Main mechanical components. Manufacturing technologies.
MODULE 5: Navigation and motion control of mechatronic mobile bases (about 22 hours)
Holonomic and non-holonomic constraints. Classification of mechatronic mobile bases and kinematic and dynamic model description. Motion planning techniques. Control strategies and examples of autonomous navigation algorithms
MODULE 6: Medical Devices (about 16 hours)
This module introduces learners to the life cycle of medical devices, delving into specific aspects of particular importance for biomedical engineers such as: design, the regulatory framework, and the assessment and reduction of environmental impact. The module concludes with a series of examples of medical device design for global health. This module will be organized into interactive seminars, where learners will be encouraged to explore the most interesting parts of the life cycle in greater depth.

MODULE 7: Laboratory project (about 26 hours).
Experimental project developed by the student. The project can be carried out at the Teaching Laboratory and at the Advanced Robotics and Human-Centered Technologies laboratory of Università Campus Bio-Medico di Roma.

Metodi didattici

Frontal lessons regarding theoretical knowledge: these lessons will consist of around 90 hours of lectures.
Exercises in the classroom or in the laboratory to teach practical competences necessary for biomechatronic design and development.
Laboratory activities to train the capacity of the student to apply theoretical knowledge.
Group project to train team-working skills.
Students are split into groups (max student number:11). The groups are asked to design and develop a solution to a specific problem defined at the beginning of the second semester.
The Laboratory lessons and group work will consist of about 54 hours.

Modalità di verifica dell'apprendimento

The knowledge and competencies acquired by the student will be assessed through the evaluation of a practical group project and an individual oral exam.
The group project consists of integrating a mechatronic platform capable of performing a specific desired task. The project examination is passed if the mechatronic platform, developed by the group, is capable of successfully accomplishing the desired task. A final ranking is made to assign the grade to the group project, considering multiple performance indicators such as the completion time, energy consumption etc. In case of failure, i.e. if the task is not successfully accomplished by the mechatronic platform, a final grade of 18 is assigned to the group.
During the individual oral exam, two independent examiners assess each student. The first examiner checks the acquired knowledge. The second examiner asks details about the final project to test student's skill and her/his practical capabilities. Each examiner can assign a maximum grade of 33 points and the score of the overall oral exam is the average of the two examiners' scores.

Testi di riferimento

Class notes and materials provided by the professor through the institutional e-learning platform:
http://elearning.unicampus.it.

Altre informazioni

- Knowledge and understanding: Knowledge of the main characteristics and components of mechatronic devices for applications in biomedicine; knowledge of the main design techniques of mechatronic systems and of its most relevant fabrication technologies.
- Applying knowledge and understanding: capability to define the requirements and the technical specifications of a mechatronic system; capability to select and choose the most appropriate components available on the market for a given application and to design the mechanical and electronic components not readily available.
- Making judgements: capability to elaborate and evaluate autonomously the different design solutions that are available during the design process of a mechatronic system, by assessing the main advantages and drawbacks of each solution; capability to assess the functionalities and the performance of a mechatronic system with respect to a given list of requirements.
- Communication skills: skills that allow students to clearly explain, using an appropriate technical/scientific terminology, the characteristics of the main components of a mechatronic device (sensors, actuators, microcontrollers, firmware); capability to present in a clear and exhaustive way the design choices done during the laboratory project.
- Learning skills: the methodology provided during the lectures and the lab sessions should allow students to autonomously use new electronic and mechanical components, beyond the ones presented during the class lessons, and to design parts of a mechatronic system according to the given requirements.

L'attività didattica è offerta in:

Facoltà Dipartimentale di Ingegneria

Tipo corso	Corso di studio (Ordinamento)	Percorso	Crediti	S.S.D.
Corso di Laurea Magistrale	Master of Science in Biomedical Engineering (2019)	Common	18	ING-IND/34

Stampa del 07/05/2025

Mechanics of Biological Systems [2201232]

Offerta didattica a.a. 2024/2025

Docenti: ALESSIO GIZZI

Periodo: Primo Ciclo Semestrale

Obiettivi formativi

The course aims at providing knowledge and understanding of basic criteria of theoretical and computational biomechanical modeling (soft fiber-reinforced tissue, muscle and cardiac electromechanics) and the methodologies and skills for the critical analysis of scientific literature in the biomechanical field. In addition, the course aims at introducing the student to the writing of a scientific report.

Prerequisiti

No specific propaedeutic course. Recommended notions of continuum mechanics, materials, anatomy, and physiology.

Contenuti del corso

The course is organized in a unique module subdivided into
• Introduction to continuum mechanics in large deformations (10h): generalized kinematics and multiplicative decomposition; derivation of constitutive equations from a thermodynamical potential; hyperelastic materials and non-equilibrium behavior.
• Multi-physics and multi-scale biomechanical models of biological systems (30h): multiphysics formulations (electro-mechanics, thermo-mechanics, plasticity, fracture) via the multiplicative decomposition of the deformation gradient and the additive decomposition of the energy potential; homogenized multiscale modeling of cells, tissues and organs (collagen fibers, muscular fibers); statistical description of biomechanical properties of soft tissues though averaged structure tensors; state-of-the-art of mechanobiology and future challenges.
• Solution methods of biomechanical models of biological systems (20h): reconstruction and discretization of physical domains from biomedical images; variational formulation and implementation of finite elements solvers.

Metodi didattici

Lectures (4 CFU) introducing the course arguments, presenting and discussing cases of study taken from the specific scientific literature.
Flipped classroom (1 CFU) addressing specific themes in the biomechanical field.
Advanced seminars (1 CFU) delivered from international renowned experts from research and industry.

Modalità di verifica dell'apprendimento

The knowledge and skills learned during the course will be assessed through a project test, developed during the course, and through an oral test, at the end of the course.
The project test (graded at most 15/30 which engages the student during the course with his own study and constant multiple meetings with the teacher) will focus on the preparation of a scientific report (max 10 pages) on a specific topic of current biomechanical research. In the report, students will have to apply previous notions of mechanics, anatomy and physiology as well as understanding a text in English. Students are expected to apply the notions acquired during the course and to be able to critically develop the study topics to evaluate their theoretical and applied understanding, ability to learn and autonomy of judgment.
The oral exam (graded at most 15/30 which takes the student for 10 minutes followed by about 10 minutes of questions and discussion of the topics presented) will verify the degree and learning of the knowledge provided to the student in terms of tissue biomechanics and organs, finite elasticity, theoretical-computational modeling and provides that the student orally illustrates the scientific report on the basis of supporting slides projected during the test using the scientific technical language acquired during the course. The student is expected to acquire communication skills in the English language.

Testi di riferimento

Reference Textbooks:
1) Nonlinear Solid Mechanics: A Continuum Approach for Engineering, G.A. Holzapfel, ISBN: 978-0-471-82319-3, 2000.
2) Nonlinear Theory of Elasticity: Applications in Biomechanics, L.A. Taber ISBN-10: 9812387358
3) An Introduction to Biomechanics: Solids and Fluids, Analysis and Design, J.D. Humphrey ISBN-10: 1493926225
Lecture notes from the lecturer.

Presentations from the lecturer and from international experts.

Altre informazioni
Specific learning outcomes:
Knowledge and understanding. The course will provide the necessary elements to understand the theoretical-scientific foundations of biomechanical modeling of biological materials and systems from the micro- to the macro-scale, with specific attention to the biomedical applications.
Applying knowledge and understanding. The students will acquire the required knowledge to understand scientific treatises and their transposition into biomechanical mathematical models in view of the numerical simulations of physiological and pathological behaviors of tissues, organs, and biological systems, in general. Thanks to innovative teaching methodologies, the students will learn how to introduce a theme to the whole class developing skills of rational thinking at the basis of the building of biomechanical models.
Making judgements. Students will be conducted to develop their own analytical and critical skills, learning the required knowledge for the evaluation of biomechanical models in biomedical applications.
Communication skills. At the end of the course, the students will develop communicative skills such as setting up a dialog with international experts in biomechanical research by using scientific jargon.
Learning skills. Students will be able to retrieve information from the specific scientific literature and will be able to build up biomechanical models of biological systems.

L'attività didattica è offerta in:

Facoltà Dipartimentale di Ingegneria

Tipo corso	Corso di studio (Ordinamento)	Percorso	Crediti	S.S.D.
Corso di Laurea Magistrale	Master of Science in Biomedical Engineering (2019)	Nanotechnology and Bioartificial Systems	6	ICAR/08

Stampa del 07/05/2025

Measurements and Instrumentation for Clinical Diagnostics [2201139]

Offerta didattica a.a. 2024/2025

Docenti: SERGIO SILVESTRI, VALERIO CUSIMANO

Periodo: Primo Ciclo Semestrale

Obiettivi formativi
The aim of the course is to provide the student with the information necessary for the knowledge of the principles on which the most widely used biomedical instrumentation in the clinical setting is based. The training aspect on the fundamentals is supplemented by the analysis of the main technologies and the in-depth study of the design structure of the equipment for the purpose of carrying out the diagnostic or therapeutic support function. The phenomena of patient-equipment and equipment-implant interaction are analyzed with particular regard to what is inherent to diagnostic quality and safety.
Furthermore, it allows to increase the ability to identify real problems (experience of the factum rationis) and solve them with professional competence. It allows the student to practice hierarchizing the observed problems (to test their axiological system) and to experience what it means to put the finis operis at the service of the finis operantis (unity of life in the exercise of the profession).

Prerequisiti
None

Contenuti del corso
Biomedical Measurements and Instrumentation
Introduction (3 hours lesson)
Biomedical instrumentation: purpose, design and use. The clinical engineer and his training. The hospital system: ways of operating of the different professionals. Duties of the clinical engineer: technical and economic assessments of biomedical instrumentation, operational safety, maintenance management. Technological advancement. Man-machine and machine-plant interface.
Measurements of the characteristic parameters of pulmonary mechanics (6 hours lesson)
Mechanical behavior of the lungs. Modeling. Fundamental quantities of pulmonary mechanics. Spirometry. Pneumotachography. Plethysmography.
Anesthesia machines (5 hours lessons, 1 hour practice)
Introduction and principle of operation. Principle scheme. Main anesthetic agents. Vaporizer. Patient circuit closed and open.
Pulmonary ventilators (5 hours lesson, 1 hour practice)
Principle scheme of a pulmonary ventilator. Methods of detection of respiratory parameters. Ventilation models and techniques. High frequency ventilation. Ventilators for anesthesia and intensive care. Gas analysis. Humidification.
Blood pressure measurement (4 hours lesson)
Introduction and physiology. Non-invasive methods: pulse, auscultatory, oscillometric method. Considerations on the causes of uncertainty with non-invasive methods. Invasive methods, causes of uncertainty, analysis of the metrological characteristics of the measurement system with catheter.
Electrocardiograph and electroencephalograph (6 hours lesson)
Detection of cardiac potentials. Principle diagram of an electrocardiograph. Performance of electrocardiographs. Poly-channel electrocardiographs. The electroencephalogram. EJB. System 10-20. Evoked potentials. Digital electroencephalographs.
Pacemaker (3 hours lesson)
Pacemaker function and principle scheme. Synchronous and asynchronous pacemaker. ICHD Code. Diet. Leads. Pacemaker programming and patient monitoring.
Defibrillator (5 hours lesson)
Defibrillator in alternating and direct current. Synchronized use. Implantable Defibrillators.
Infusion pumps (3 hours lesson)
Introduction and method of infusion. Gravimetric method. Linear and rotary peristaltic pumps. Functional diagram of a drop control pump. Performance of the pumps. Continuity Variance.
Electrosurgical unit (6 hours lesson)
Effects of current in the human body. Cutting, coagulation and mixed techniques. Classification of electrosurgical units. Neutral electrode. Principle diagram of the electrosurgical-patient circuit. Risks of leakage current.
Applied ethics:
Introduction and Axiological System for Biomedical Engineering (2 hours lesson)
Principle of connecting the ends (Finis Operis and Finis Operantis) (2 hours lesson)

Training in the various departments of the hospital under the supervision of a doctor from the polyclinic (16 hours)
Brainstorming (4 hours)

Metodi didattici
Lectures in which the topics of the course are described and analyzed with the aid of practical examples that show their application to specific problems (50 hours). Application-type demonstration exercises in the laboratory (2 hours). Training in the various departments of the hospital under the supervision of a doctor from the polyclinic (16 hours). Brainstorming (4 hours).

Modalità di verifica dell'apprendimento
Learning evaluation methods and criteria:
The student will have to hierarchize the topics he exposes with language properties and will have to show a critical approach on the elaboration and understanding of concepts through questions on the topics of the course program, he will have to present the topics in a clear, appropriate, concise and effective way.
Biomedical Measurements and Instrumentation: The knowledge, understanding and skills acquired are verified through an oral test in which it is required to present specific topics, concerning biomedical instrumentation for clinical use, knowledge of the operating principles and some technological details of the instrumentation biomedical, as well as knowing how to apply the concepts learned to concrete cases.
Applied Ethics: The knowledge, understanding and skills acquired are verified by means of an oral test in which the student is asked to present through a power point presentation 1) the problem identified during the period spent in the wards of the polyclinic, 2) the solutions found by the student to solve the identified problem, 3) the ethical evaluation of the best solution using the Axiological System. At least two days before the oral exam, the student must send a paper to the teacher of the module which will report: the problem identified and the solutions found. A template of the thesis will be provided to students to use as an example.
It is possible to take the verification of the Biomedical Measurements and Instrumentation module only after having positively supported the verification of the Applied Ethics module.
Criteria for measuring learning and awarding the final grade:
Biomedical Measurements and Instrumentation: teachers will be asked to present two topics, for a maximum duration of 1 hour. For each topic, on the basis of questions of increasing difficulty posed by the teacher, the student will have to demonstrate knowledge about the topic and the solidity of the basic knowledge that are its foundation, they may be asked to demonstrate competence in the application of knowledge to concrete cases. To each topic the teachers will assign up to a maximum of 31 points. The grade obtained is expressed out of thirty and the exam is passed only if a grade greater than or equal to 18/30 is obtained. At the end of the questioning, the assessment assigned will be the average of the points obtained by the student for each topic.
Applied Ethics: The teachers will assign a score of up to a maximum of 26 points to the presentation and a score of up to 5 points to the essay. The grade obtained is expressed out of thirty and the exam is passed only if a grade greater than or equal to 18/30 is obtained. The assigned evaluation will be the sum of the points obtained by the student for the presentation and the essay.
It is possible to take the verification of the Biomedical Measurements and Instrumentation module only after having positively supported the verification of the Applied Ethics module.
On the final grade the Applied Ethics evaluation will weigh 1/3 and the Biomedical Measurements and Instrumentation evaluation will weigh 2/3. Honors will be awarded for a final score higher than 30.

Testi di riferimento
F.P. Branca, “Fondamenti di Ingegneria Clinica” Vol. I, Springer
J. G. Webster “Medical Instrumentation: Application and Design” Wiley
Ethics: Lecture notes
Additional teaching material will be communicated by the teacher at the beginning of the lessons and / or uploaded to e-learning

Altre informazioni
KNOWLEDGE AND UNDERSTANDING
The course aims to provide knowledge on the basic concepts regarding biomedical instrumentation for clinical use, knowledge of the operating principles and some technological details of the most widespread biomedical instrumentation used in the health sector.
KNOWLEDGE AND UNDERSTANDING APPLIED
The student must be able to describe the operating principle of a biomedical equipment also in relation to human physiology. They must be able to choose and evaluate the use of a system aimed at meeting specific measurement or monitoring needs in the clinical setting.
Increase the ability to identify real problems (experience of factum rationis) and solve them with professional competence.
Practice hierarchizing the observed problems (testing one's axiological system).
Experience what it means to put the finis operis at the service of the finis operantis (unity of life in the exercise of the profession).
AUTONOMY OF JUDGMENT
The student will be stimulated to develop a critical approach on the elaboration and understanding of concepts

through questions on the topics of the course program.
COMMUNICATION SKILLS
The student will have to learn how to present the arguments in a clear, appropriate, concise and effective way. He will have to organize the exhibition in a logical way starting from the basic knowledge required to develop the topic comprehensively.
ABILITY TO LEARN
The student will have to develop a growing ability to learn through a study methodology that makes attendance to lessons and exercises productive, through active participation in them.

L'attività didattica è offerta in:

Facoltà Dipartimentale di Ingegneria

Tipo corso	Corso di studio (Ordinamento)	Percorso	Crediti	S.S.D.
Corso di Laurea Magistrale	Master of Science in Biomedical Engineering (2019)	Common	9	ING-IND/12, MED/43

Stampa del 07/05/2025

Nanotecnologie in Biomedicina [2201146]

Offerta didattica a.a. 2024/2025

Docenti: ALBERTO RAINER

Periodo: Secondo Ciclo Semestrale

Obiettivi formativi
The course will provide students with the elements to understand the properties of nanoscale materials, especially for what concerns their application in biomedicine.

Prerequisiti
Basic knowledge in chemistry and materials science is recommended.

Contenuti del corso
Introduction of Bionanoscience and Bionanomaterials (30h): peptide/polypeptide/protein nanomaterials; virus/cell based nanotechnologies; quantum dots; polymeric and metal nanoparticles; carbon based nanomaterials; assembly principle of biological materials.
Applications to nanomedicine (10h).
Electron microscopies, confocal microscopy and scanning probe microscopies (8h).

Metodi didattici
Lectures introducing the course topics, integrated by seminars/webinars on research aspects of bionanotechnologies (40h). Lab tutorials and online “live demos” on microscopic characterization techniques (8h).

Modalità di verifica dell'apprendimento
Knowledge assessment methods and criteria:
Knowledge will be assessed by means of a written test with 3 open-ended questions.
The test aims to assess:
• Knowledge and understanding of the subject
• Capacity of applying knowledge and understanding to real world problems in the field of nanotechnologies in biology and medicine
• Communication skills, such as the capacity to provide both specialistic and non-specialistic audience with unambiguous explainations
• Ability to autonomously perform evaluations in the use of nanotechnology-based solutions to medical and biological problems.
• Ability to autonomously extend knowledge by accessing the literature

Criteria for measuring learning and defining the final grade:
To get a pass, students must demonstrate sufficient knowledge of the course contents. Higher marks (above 27 out of 30) will be given to those students who will correlate the theoretical knowledge with the current research challenges in the field
Honors (lode) will be given to those students who obtain 30 out of 30 and show excellent presentation skills, using graphs and schemes.

Testi di riferimento
Handouts and selected publications available at http://elearning.unicampus.it
The following textbooks are also suggested.
- F. Rossi, A. Rainer, Nanomaterials for Theranostics and Tissue Engineering: Techniques, Trends and Applications, Springer.
- D. Vollath, Nanomaterials: an Introduction to Synthesis, Properties, and Applications, Wiley

Altre informazioni
Knowledge and understanding
• Knowledge of the most relevant nanotechnology-based solutions in biology and medicine
• Knowledge of the most relevant nano-characterization techniques

Applying knowledge and understanding
• Ability to design nanomaterials for biomedical applications

Making judgements
• Ability to autonomously perform choices in the design of nanotechnology-based solutions.

Communication skills
• Ability to communicate with professionals in the field of nanomaterials using a technical vocabulary

Learning skills
• Ability to autonomously extend knowledge by accessing the literature.

L'attività didattica è offerta in:

Facoltà Dipartimentale di Ingegneria

Tipo corso	Corso di studio (Ordinamento)	Percorso	Crediti	S.S.D.
Corso di Laurea Magistrale	Master of Science in Biomedical Engineering (2019)	Nanotechnology and Bioartificial Systems	6	ING-IND/34

Stampa del 07/05/2025

Ergonomic Design Principles [2201141]

Offerta didattica a.a. 2024/2025

Docenti: LOREDANA ZOLLO

Periodo: Secondo Ciclo Semestrale

Obiettivi formativi

This course has the main purpose of introducing to the field of Ergonomics, and providing the Student with:
(1) sound theoretical knowledge for analysing, modeling, and designing workplaces with a “user-centred” approach, aiming at optimizing human well-being and overall system performance;
(2) abilities summarized as follows:
(i) practical bases on workplace ergonomic analysis, evaluation and design, with special emphasis on industrial production lines and office workplace;
(ii) practical competences on the tools for modeling and design.

Prerequisiti

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Contenuti del corso

• Introduction (4 hours) – Definition and objectives of ergonomics; Description of the main intervention areas (physical, cognitive, organizational).
• Fundamentals of Ergonomics (10 hours):
Elements of Anthropometry: static and functional anthropometric data; databases and scaling techniques; reachability areas and volumes;– Elements of biomechanics: movements, static and dynamic muscular activity, muscle force, standing and seated posture;– Elements of work physiology: activity metabolic cost, thermal environments, illumination, noise; – Human action and error.
• Workplace design (30 ore):
User-centred design; Design of industrial production lines; Office design; Work measurement e speed accuracy trade-off; Regulations and Standard for the evaluation of activities of load manual handling, upper-limb repetitive movements, and static postures (ISO 11228-1, ISO 11228-2, ISO 11228-3, ISO 11226)
• Human-Machine Interaction (4 hours):
Principles of human-machine interaction; Human-oriented evaluation of collaborative robots and exoskeleton.

Metodi didattici

Lectures (32 hours) on the topics of the course and case studies on their application to specific problems.
Seminars (4 hours) on specific applications of ergonomics (e.g. industrial production lines and office workplace).
Classroom tutorials and practical sessions (12 hours) to teach the use of hardware and software tools for ergonomic analysis, evaluation and design.

Modalità di verifica dell'apprendimento

Knowledge acquired during the course is evaluated through an oral exam with closed stimulus and open stimulus.
The assessment of the acquired knowledge will be carried out by a commission composed of the teachers, who will verify the knowledge of the theoretical aspects of the course, and the course assistants, who will verify students' capabilities to apply the theoretical knowledge to a practical problem.
The oral exam aims to prove:
1. Knowledge and understanding of the course topics.
2. Ability to apply the knowledge and skills acquired in the formulation of solutions (even original ones) to ergonomic design problems.
3. Ability to apply the methods and tools presented during the course for the solution of ergonomic assessment and design problems.
4. Communication skills in the formal description of the course topics, expressing clearly and unambiguously their conclusions, and the knowledge and considerations underlying them, to specialist and non-specialist interlocutors in national and international contexts.
5. autonomy of judgment in the choice of solutions to ergonomic design problems and ability to manage complex technical or professional activities or projects in their field of study and to take responsibility for making decisions.
6. the ability to engage autonomously in lifelong learning.

The oral exam has a maximum duration of 45 minutes.

During the oral exam, the commission will ask three questions aimed at verifying students' knowledge of the course topics . All the questions have the same weight in the evaluation (i.e. 11 points for each).
The exam is passed if the candidate reaches at least 18/30.
The final evaluation is formulated as the sum of the scores for the three questions. Honors will be given in case of full marks for all the examinations and a final score higher than 30.

Testi di riferimento

MS Sanders, EJ McCormick "Human Factors In Engineering and Design"- Mc Graw Hill.
D Meister, TP Enderwick "Human factors in system design, development and testing" – Taylor & Francis
Lecture notes provided by the teacher.

Further readings:
Donald A. Norman, La caffettiera del Masochista, Editore: Giunti, Anno edizione: 1997, ISBN: 88-09-21027-1.

Altre informazioni

Knowledge and understanding
• Fundamentals of the "user-centred" ergonomic design.
• Methods and tools for the risk assessment due to biomechanical overload, ergonomic standards and directives, principles of risk reduction in working scenarios
• Principles of ergonomic design of the workplace, risk management and safety in working environments.

Applying knowledge and understanding:
• Capability to apply a "user-centred" approach to the design of machines, systems and environments conceived for interaction and cooperation with humans in working scenarios.
• Capability to apply typically adopted methods and tools for the risk assessment due to the biomechanical overload, the ergonomic standards and directives, and the principles of risk reduction in working scenarios.
• Capability to design the workplace according to the ergonomic standards and directives, and to manage risks and safety with advanced methods.

Autonomy in judging:
Students will be encouraged to develop their analytical and critical skills by proposing exercises on the topics explained during lectures, and activities of ergonomic analysis and evaluation by means of tools for behavioral analysis and modeling.
Learning skills:
The course relies on an approach based on the active involvement of the students by promoting re-examination and in-depth analysis of competences acquired in previous studies, and the application of the learnt concepts in other specific areas.
Communication abilities and soft skills:
The course wants to promote the development of communication abilities and soft skills to work in team and in multidisciplinary settings. This goal will be pursued by soliciting pro-active involvement of the students during the lectures and carrying out practical activities requiring practical implementation of the learnt teoretical issues.

L'attività didattica è offerta in:

Facoltà Dipartimentale di Ingegneria

Tipo corso	Corso di studio (Ordinamento)	Percorso	Crediti	S.S.D.
Corso di Laurea Magistrale	Master of Science in Biomedical Engineering (2019)	Biorobotics and Ergonomics	6	ING-IND/34

Stampa del 07/05/2025

Industrial and Medical Robotics [2201142]

Offerta didattica a.a. 2024/2025

Docenti: LOREDANA ZOLLO

Periodo: Ciclo Annuale Unico

Obiettivi formativi
This course has the main purpose of introducing to the field of Industrial and Medical Robotics, and providing the Student with:
(1) sound theoretical knowledge for analysis, modeling, design and development of robotic systems for medical and industrial applications;
(2) abilities summarized as follows:
(i) practical bases on the development and control of robotic machines;
(ii) practical competences on the tools for modeling and design of robotic systems.

Prerequisiti
Matlab fundamentals

Contenuti del corso
• Introduction (2 hours) - Definition of industrial robotics and medical robotics; Manipulator structures and main components.
• Fundamentals of Robotics (64 hours):
– Robot kinematics - Elements of matrix algebra; Kinematic pairs; Holonomic and nonholonomic constraints; Introduction to analysis and synthesis of kinematic mechanisms; Elements of rigid body kinematics; Position and orientation of rigid bodies; Rotation matrices, Euler angles, angle and axis, unit quaternion; Forward kinematics.
– Differential kinematics and statics – Differential kinematics; Geometric Jacobian and analytical Jacobian; Kinematic singularities; Analysis of Redundancy; Inverse kinematics and inverse kinematics algorithms; Statics; Manipulability Ellipsoids.
– Robot Dynamics - Computation techniques of robot dynamic model; Lagrange formulation; Forward and inverse dynamics; Properties of dynamic model; Operational space dynamic model; Methods for dynamic parameter identification and extraction from CAD.
– Trajectory planning – Joint space trajectories; Operational space trajectories.
– Robots control systems - Voltage control; Torque control; Joint space control; Operational space control; PID control; PD control with gravity compensation; Inverse dynamics control.
– Interaction control - Direct and indirect interaction control schemes: classification and mathematical formulation; Compliance control; Impedance control; Force control.
– Visual servoing - Main techniques of visual servoing with emphasis on the kinematic approach named "image-based visual servoing".
• Neural Networks (2 hours) - Notion of neuron (structure and functioning) and artificial neuron; Artificial neural networks (main features, functioning, classification of architectures and learning algorithms, applications, case-studies in neuroscience and robotics); Central Pattern Generator (examples in animal world, examples of robotic applications, design methodologies). Application of neural networks and CPG: cyclic manipulation.
• Rehabilitation Robotics (2 hours) - Definition and applications (neuro-rehabilitation and assistance); general concepts.
• Robotics for diagnosis and surgery (24 hours) - Definition and applications (MIS, MIT, CAS); surgery and telesurgery; Classification of surgical robots; Haptic feedback and haptic interfaces; Master-Slave systems; Case studies of robots for surgical applications (e.g. Da Vinci robot, Zeus , KUKA/LWR, Phantom, Novint Falcon): kinematics, dynamics and control. Control architecture for teleoperated robotic systems.

Metodi didattici
Lectures (80 hours) on the topics of the course and practical exercises on their application to specific problems.
Seminars (10 hours) on specific biomedical applications of robotics (e.g. upper- and lower-limb prosthetics, robotic surgery, robot-aided rehabilitation).
Classroom tutorials and laboratory sessions (25 hours) to teach the use of hardware and software tools for robot design and control (MATLAB, Simulink, Python, Lego Mindstorm EV3).
Classroom tutorials (5 hours) to provide the students with the tools needed for performing the intermediate test scheduled at the end of the first semester.
Group projects where students will apply competencies acquired during the lectures. The groups will be composed of 7 students at the maximum. They will be required to develop a robotic system for the execution of a specific task

defined at the beginning of the course. Each group will build a robotic system (by means of Lego Mindstorm EV3) and develop software modules for motion planning and control in MATLAB/Simulink environment.

Modalità di verifica dell'apprendimento

Knowledge acquired during the course is evaluated through an oral exam, a written test, and the presentation of a practical exercise of robot design and control by using the Lego Mindstorm EV3 kit, MATLAB and Simulink.
At the end of the first semester, it will be possible to participate in an intermediate test for the evaluation on the following topics: forward and inverse kinematics, differential kinematics, statics and trajectory planning. It consists of a written test partly with closed stimulus and closed response and partly with closed stimulus with open response.
The assessment of the acquired knowledge will be carried out by the teacher, who will verify the knowledge of the theoretical aspects of the course, and by the course assistants, who will verify students' capabilities to apply the theoretical knowledge to a practical problem, through the discussion of the practical exercise.
The oral exam is both closed stimulus and open stimulus and with open response. During the oral exam, the teacher will ask three questions, in written or verbal form, aimed at verifying students' knowledge of theoretical issues. Two questions will regard the module of Fundamentals of Robotics, while one question will cover the other modules. All the questions have the same weight in the evaluation (i.e. 11 points for each).
The presentation of the practical exercise consists of a demo of the robotic system developed with Lego Mindstorm EV3 kit and a description of the applied methods and the achieved results by means of slides. All the practical exercises will be presented and discussed at the end of the course and, however, before the first date of the oral exam. During the discussion, specific questions for each student of the same group will be asked in order to assess the individual contribution to the overall work.
The oral exam and the discussion of the projects aim to prove:
1. Knowledge and understanding of the course topics.
2. Ability to apply the knowledge and skills acquired in the formulation of solutions (even original ones) to design and development of robotic systems.
3. Ability to apply the methods and tools presented during the course for solving robot modeling and control problems.
4. Communication skills in the formal description of the course topics, expressing clearly and unambiguously own conclusions, the knowledge and considerations underlying them, to specialist and non-specialist interlocutors in national and international contexts
5. Autonomy of judgment in the choice of solutions to robot design and development problems and ability to manage complex technical or professional activities or projects in their field of study and to take responsibility for making decisions.
6. Ability to engage autonomously in lifelong learning.

The oral exam has a maximum duration of 45 minutes and the presentation of projects of 30 minutes.

The final evaluation is formulated according to the following rule:
13/15 of the final score will be assigned based on the oral exam;
2/15 of the final score will be assigned based on the presentation of the developed robot.

In the case of positive evaluation of the intermediate test:
10/15 of the final score will be assigned based on the oral exam;
3/15 of the final score will be assigned based on the intermediate test;
2/15 of the final score will be assigned based on the presentation of the developed robot.
Honors will be given in case of full marks for all the examinations and a final score higher than 30.

Testi di riferimento

B. Siciliano, L. Sciavicco, L. Villani, G. Oriolo, Robotics - Modelling, Planning and Control, Springer 2010.
M. Tavakoli, R.V. Patel, M. Moallem, A. Aziminejad, Haptics for Teleoperated Surgical Robotic Systems, New Frontiers in Robotics series, World Scientific, 2008.
Lecture notes provided by the teacher.
Further readings:
R. M. Murray, Z. Li and S. S. Sastry, A Mathematical Introduction to Robotic Manipulation, CRC
Press, 1994.
B. Siciliano, L. Villani, Robot force control, Kluwer, Academic Publishers, Boston, 1999.
D.M. Gorinevsky, A.M. Formalsky, A. Yu. Schneider, Force control of robotics systems, CRC Press, Boca Raton, 1997.
J. J. Craig, Introduction to Robotics - Mechanics and Control, Pearson Prentice-Hall, 2005.
B. Siciliano and O. Khatib Eds., Handbook of Robotics, Springer 2008
J. Rosen, B. Hannaford, R.M. Satava, Surgical Robotics – Systems Applications and Visions, Springer 2011.

Altre informazioni

Knowledge and understanding
• Fundamentals of robotics, functioning schemes and methods for analysis, modelling, design and development
• Software tools for design and modeling robotic systems

Applying knowledge and understanding:
• Capability to apply methods and tools of electronics, computer science, automation and mechanics to the analysis of complex systems such as robotic systems for industrial and medical applications.
• Capability to develop, with advanced methods, robotic systems that include the human component and propose novel solutions for simple components or for the integrated system.
• Capability to use software tools for simulation, modeling, and control of robotic systems for biomedical applications and for human-robot interaction.

Autonomy in judging:
Students will be encouraged to develop their analytical and critical skills by proposing exercises on the topics explained during lectures, and activities of design and development of simple robotic structures with educational kits.

Learning skills:
The course relies on an approach based on the active involvement of the students by promoting re-examination and in-depth analysis of competences acquired in previous studies, and the application of the learnt concepts in other specific areas.
Communication abilities and soft skills:
The course wants to promote the development of communication abilities and soft skills to work in team and in multidisciplinary settings. This goal will be pursued by soliciting pro-active involvement of the students during the lectures and group projects requiring practical implementation of the learnt theoretical issues.

L'attività didattica è offerta in:

Facoltà Dipartimentale di Ingegneria

Tipo corso	Corso di studio (Ordinamento)	Percorso	Crediti	S.S.D.
Corso di Laurea Magistrale	Master of Science in Biomedical Engineering (2019)	Common	15	ING-IND/34

Stampa del 07/05/2025

Diagnostic Equipment for NUclear Medicine [2201234]

Offerta didattica a.a. 2024/2025

Docenti: LUCIANO MIRARCHI

Periodo: Secondo Ciclo Semestrale

Syllabus non pubblicato dal Docente.

L'attività didattica è offerta in:

Facoltà Dipartimentale di Ingegneria

Tipo corso	Corso di studio (Ordinamento)	Percorso	Crediti	S.S.D.
Corso di Laurea Magistrale	Master of Science in Biomedical Engineering (2019)	Common	6	ING-INF/05

Stampa del 07/05/2025

Clinical Imaging Instrumentation [2201130]

Offerta didattica a.a. 2024/2025

Docenti: SERGIO SILVESTRI

Periodo: Secondo Ciclo Semestrale

Obiettivi formativi
Aim of the course is to provide the student with the knowledge of the principles on which the diagnostic imaging equipment most used in hospitals is based. The training aspect on the fundamentals is supplemented by the analysis of the main technologies and the in-depth study of the design structure of the equipment for the purpose of carrying out the diagnostic function.

Prerequisiti
None

Contenuti del corso
The physics of X-radiation and biological damage (10 h)
Introduction. Description of a radiological installation. The electromagnetic radiation X. Emission spectrum. Absorption. Attenuation coefficient. Contrast, resolution and SNR. Dosimetric quantities. Biological actions of ionizing radiation.

The generation of X-rays and the X-ray tube (4 h)
Constitution of the X-ray tube. Rotating anode. Load diagrams. Focal spot and its measure.

The power supply of the X-ray tube and the formation of the radiographic image (8 h)
The power supply of the X-ray tube. Rectifiers and electric power control. The radiographic film. Developers and sensitometric curve. Quality characteristics of the radiographic image. FTM. Image intensifiers.

The technology of the radiological device (3 h)
Principle diagram of a traditional radiological device. Transformer-tube coupling. Exposure times. High frequency power supply.

Analog and digital radiology (5 h)
The television chain. The video signal - resolution. Digital radiology. Comparison between digital and analog systems. Image processing, storage and presentation.

Principles of tomography (2 h)
General principles of tomography. Stratigraphy. Special equipment. Stereotaxis.

Computed axial tomography (6 h)
The physical principles underlying the formation of the reconstructed image. Attenuation and HU units. The sinogram. Detectors. Tomographic reconstruction.

Ultrasound tomography (4 h)
The physics of ultrasound. Characteristic acoustic quantities. The propagation of ultrasound, diffusion and transmission of radiation. Ultrasound probes. Axial and lateral resolution. The formation of the ultrasound image. Echo-Doppler. Color and Power Doppler.

Magnetic Resonance Imaging (4 h)
The phenomenon of magnetic resonance. Relaxation times. Gradients. The formation of the image, the k-space. Sequences. Magnetic resonance tomograph.

Metodi didattici
Lectures in which the topics of the course are described and analyzed with the aid of practical examples that show their application to specific problems (46 hours). Demonstration exercise on radiological system (2 hours).

Modalità di verifica dell'apprendimento
Learning evaluation methods and criteria:

The knowledge, understanding and skills acquired are verified through an oral test in which it is required to present specific topics and to know how to apply the concepts learned to concrete cases. The student will have to hierarchize the topics s/he exposes with proper language and will have to show a critical approach to the elaboration and understanding of concepts through questions on the topics of the course program. The student must present the arguments in a clear, appropriate, concise and effective way.
The topic of Magnetic Resonance Tomography is excluded from the learning assessment.

Criteria for measuring learning and awarding the final grade:

In order to evaluate the knowledge, understanding and skills acquired, each student will be asked to present two topics by the teachers for a maximum duration of 1 hour. For each topic, on the basis of questions of increasing difficulty posed by the teacher, the student will have to demonstrate knowledge and understanding of the topic as well as the solidity of the basic knowledge that is its foundation, possibly they may be asked to demonstrate competence in application of knowledge to concrete cases. For each topic the teachers will assign up to a maximum of 31 points. At the end of the questioning, the grade assigned will be the average of the points obtained by the student for each topic. The grade obtained is expressed out of thirty and the exam is passed only if a grade greater than or equal to 18/30 is obtained. Honors will be awarded for a final score higher than 30.

Testi di riferimento

F.P. Branca, “Fondamenti di Ingegneria Clinica” Vol. I, Springer.
J.T. Bushberg et al. “The Essential Physics of Medical Imaging” LWW
A.B. Wolbarst, G. Cook "Physics of Radiology"

Altre informazioni

KNOWLEDGE AND UNDERSTANDING
The course aims to provide knowledge on the basic concepts regarding diagnostic imaging equipment, knowledge of the operating principles and some technological details of the most widespread and used instrumentation in the health sector.
KNOWLEDGE AND UNDERSTANDING APPLIED
The student must be able to describe the operating principle of a clinical diagnostic imaging tool also in relation to human anatomy and physiology. They must be able to choose and evaluate the use of a system aimed at satisfying specific measurement needs in the clinical setting.
AUTONOMY OF JUDGMENT
The student will be stimulated to develop a critical approach on the elaboration and understanding of concepts through questions on the topics of the course program.
COMMUNICATION SKILLS
The student will have to learn how to present the arguments in a clear, appropriate, concise and effective way. He will have to organize the exhibition in a logical way starting from the basic knowledge required to develop the topic comprehensively.
ABILITY TO LEARN
The student will have to develop a growing ability to learn through a study methodology that makes attendance to lessons and exercises productive, through active participation in them.

L'attività didattica è offerta in:

Facoltà Dipartimentale di Ingegneria

Tipo corso	Corso di studio (Ordinamento)	Percorso	Crediti	S.S.D.
Corso di Laurea Magistrale	Master of Science in Biomedical Engineering (2019)	Clinical Engineering	6	ING-IND/12

Stampa del 07/05/2025

Telematic Applications [2201221]

Offerta didattica a.a. 2024/2025

Docenti: PAOLO SODA

Periodo: Primo Ciclo Semestrale

Obiettivi formativi
The main objective of the course entitled “Telematic Applications” is to provide students with: i) the fundamentals of the communication technologies and protocols of a modern computer network, both at infrastructural and application level, ii) the basic concepts for the conceptual design of a network and the underlying infrastructure, iii) the necessary knowledge to face the analysis and study of a distributed computer network.

Prerequisiti
None

Contenuti del corso
Computer networks (in parentheses the fraction of hours allocated to each topic):
1. Introduction
2. ISO/OSI and TCP/IP model (~3%)
3. Physical layer, Data Link, Switch, MAC Table (~3%)
4. Network Layer, Router, Routing Table (~9%)
5. IP Addressing, subnetting, static and dynamic routing (distance vector, rip, ripv2, igrp, ospf) (~9%)
6. VLAN (~5%)
7. Transport Layer (TCP, UDP) (~8%)
8. Application, Presentation, Session Layer (HTTP, HTTPS, DNS, SMTP, POP, IMAP, Peer2Peer) (~9%)
9. Security: ACL, type of attacks, vulnerabilities, mitigation strategies (~3%)
10. Laboratory activities: setting, testing and troubleshooting in real contexts or in simulation/project environments (~35%)
11. External activity: visiting the University Hospital and its networking infrastructure (~4%)
12. Health applications: E-health in Italy (~4%)

Metodi didattici
The class consists of traditional lectures in classroom as well as of practical lessons using both open-source and proprietary software packages, as well as simulation tools.
The division between frontal teaching and practical lessons is equal to 60% -40%, respectively, except for specific needs that may arise during teaching.

Modalità di verifica dell'apprendimento
Knowledge assessment methods and criteria:
Knowledge and skills relating to the course are tested by means of two tests. The first consists of experimental work to be carried out individually during the examination in the form of a computer test using the simulation environment of a computer network, which will then be discussed during the oral interview. The aim of this test is to verify that the student has acquired the design criteria of a computer network, and the software tools for the simulation and analysis of computer networks.
The second test consists of an oral interview, the purpose of which is to verify that the student has acquired an adequate level of knowledge of network protocols and the criteria for designing a computer network.

Criteria for measuring learning and defining the final grade:
In the practical test, which lasts maximum 2 hours, the elements taken into consideration are: the logic followed by the student in solving the question, the correctness of the procedure used to solve the question, the appropriateness of the proposed solution in relation to the competences that the student is expected to have acquired by the end of the course. Each of these elements weighs equally in the assessment of the laboratory test, and the satisfaction of these aspects, at least 60%, is a necessary condition for achieving a mark of 18. Higher marks will be awarded to students whose papers meet all the above aspects, in increasing proportion.

During the oral examination, which lasts maximum 45 minutes, the elements taken into consideration are: the logic followed by the student in formulating an answer to the question, the correctness of the procedure adopted for the solution of the question, the adequacy of the proposed solution in relation to the skills that the student is expected to have acquired by the end of the course, the use of appropriate language. Each of these elements weighs equally in the assessment of the oral test, and the satisfaction of these aspects, at least 60%, is a necessary condition for achieving a mark of 18. Higher marks will be awarded to students whose tests meet all the above aspects, in increasing proportion.

The laboratory test accounts for 30% of the final grade.

In order to obtain a mark of 30/30 or higher, the student must demonstrate that he/she has acquired an excellent knowledge of all the topics covered in the course, being able to link them together in a logical and coherent manner.

Testi di riferimento

Used teaching material
• Slides of the lecturer
• Introduction to Networks, Cisco

Suggested teaching material
Reti di calcolatori e Internet. Un approccio top-down. (7a ed.), J. Kurose, K. Ross Pearson, 2017

Altre informazioni

Specific learning outcomes:
Knowledge and understanding
Basic principles of network protocols, methods and tools for a distributed computer network.
Design criteria for a computer network. Software tools for the simulation and analysis of computer networks.

Applying knowledge and understanding
The student will learn the following specific abilities:
• Know how to design and to analyze a distributed network of computers, with particular reference to topology, architecture and the main protocols used for the transmission of information between computers.
• Know how to use the fundamental components of a network, using an appropriate simulation environment.

Making judgements
The student must be able to:
• judge what are the fundamental elements of a network of computers to use to solve real application cases.
• design a network of computers in a suitable simulation environment

Communication skills
Students should know how to draw up, present and explain possible design solutions to real application cases. They also should know how to present the contents of the teaching with adequate technical language.

Learning skills
Students should develop the learning skills needed to undertake subsequent studies with a high degree of autonomy.

L'attività didattica è offerta in:

Facoltà Dipartimentale di Ingegneria

Tipo corso	Corso di studio (Ordinamento)	Percorso	Crediti	S.S.D.
Corso di Laurea Magistrale	Master of Science in Biomedical Engineering (2019)	Clinical Engineering	6	ING-INF/05

Stampa del 07/05/2025

Risk assessment and basics on law [2201037]

Offerta didattica a.a. 2024/2025

Docenti: LEO POGGI, SILVANO BARI

Periodo: Secondo Ciclo Semestrale

Obiettivi formativi
The course aims to provide students with the essential tools to understand how laws and technical regulations of interest to a biomedical engineer are prepared and implemented, what are the main terms and standards used in risk assessment and analysis, what are the methods with which to carry out proper risk management with specific reference to the sector of health and medical devices, what are the regulations on the protection of personal and health data and how to apply them to ensure their protection.

Prerequisiti
None

Contenuti del corso
This is a multidisciplinary course with strong interconnections between the subjects.
Part of the course is focused on knowledge of the elements of law necessary to understand the legal issues relating to the supply and use of medical devices and connected civil and penal liability.
Another part of the course is dedicated to the standards and methodologies of risk assessment, to the knowledge and application of the regulation on the protection of personal data, with specific reference to the health sector, to the understanding and prevention of the risks that may arise. in the processing of data in e-health.
The central part of the course, supplemented by a critical analysis of some real cases, provides the elements to understand the main terms used in the risk analysis, their correct use and estimate in some elementary cases; the general framework of the national legislative and regulatory activity relating to occupational safety; knowledge of the laws and safety regulations that regulate the various areas of some specific hospital activities.

The course contents are detailed as follows.

Introduction to the course (Prof. Leo Poggi/Prof. Silvano Bari)
Object, sources, method and fundamental definitions - Topics - Timetables and methods of conducting lessons - Questions and answers

Module A: Risk evaluation and management and personal data protection in healthcare (Prof. Silvano Bari).
Duration: 24 hours.

1. The international regulatory framework
The norms - The juridical norm (rule) and the sources of the law - The technical norm and the standards - Conformity assessment and certifications - Technical regulations and legislation – Regulation in UE
2. Penal and civil liability in the management of safety and contracts
Objective elements of the crime: the conduct, the event, the causal relationship - Subjective elements of the crime: willful misconduct, negligence, intentional intent - Civil code and occupational safety - Penal code and occupational safety - The contract, the contract work, the intellectual performance contract - Essential elements of the contract, rescission and termination - The contractual documents, the general and special specifications
3. Introduction to security, safety and risk evaluation
The approach to Security and Safety - Risk, risk management and technical standard UNI ISO 31000 - Phases of risk management - Examples of risk management in the healthcare
4. Post-accident analysis
The search for causes - Reactive analysis methods - Root Cause Analysis - Examples of Root Cause Analysis in the clinical environment - Factors that affect safety - Non-technical skills - Human factors in the perception of risk
5. The protection of personal data and “privacy” - general elements
Evolution of the legislation on Data protection and "privacy" - The new European Regulation (GDPR) - Areas of application - The Data Protection Authority - Definitions, types and examples of personal data: common data, sensitive data
6. The General Data Protection Regulation - Main aspects
The reference figures: Data controller, Data processor, Person in charge of the processing, Data Protection Officer, Data subject - Privacy by default and Privacy by design - Main obligations of the Data controller - Information and consent - The management of the rights of the Data subject

7. Personal Data Protection - Security measures, compliance and liability
Suitable security measures - Risk assessment and impact analysis - Anonymization and pseudonymization - Practical examples of security measures - Liability for caused damage: reversal of the burden of proof - How to avoid (or limit) liability - Penalties
8. Personal data protection in the health environment
The processing of data relating to health - Particularities of the health environment - Information and consent - Communication of data to the Data subject - Obligations of health professionals for data protection - The requirements of the Data Protection Authority for the respect of the dignity of patients in healthcare - Some rulings of the Authority on health issues
9. E-health and data protection
Notes on e-health: objectives - Main e-health activities - The Guidelines on online reports - Medical record, Electronic Health Record and Health File - Telemedicine
10. Data security in the clinical environment
Hospital environment and Smart hospital - Internet of things (IoT) and Internet of Medical Things (IoMT) - Medical devices: emerging data security and privacy problems - How to prevent the risk of loss / theft / blocking of health data - Daily operations
11. Learning from accidents: group work on real cases (I)
12. Learning from accidents: group work on real cases (II)

Module B: Risk evaluation and occupational safety in the health sector (Prof. Leo Poggi). Duration 24 hours

1. A first example of regulation: the industrial risk
2. European harmonization legislative acts of engineering interest
European product legislation - Horizontal harmonization legislative acts for products - Liability for defective products - General product safety - New challenges in terms of safety - List of vertical harmonization legislation for products
3. Risk analysis
Risk analysis - Hazard identification - Event, exposure - Estimation of the elements of risk - Learning from accidents
4. Risk assessment and acceptability
Risk estimate - Risk assessment - Risk acceptability - The risk faced in the system: REACH and CPL regulations
5. Risk assessment and reduction for machines
Integrated safety in the design for products - The concept of barrier - The UE 2023/1230 Regulation on machinery - Type of standards harmonized with the Machinery Regulation - Strategy for risk assessment in machinery - Introduction at the FMEA
6. Risk assessment in the workplace
Culture of prevention - Principles of health and occupational safety SSL - Recital 89/391 / EEC - Legislative decree 81/08 - General protection measures - Machinery risk in the workplace
7. The hospital as a complex building
The building: for the components, EU regulation 305; for the structure, hints on construction safety - The plants: safety integrated in the project, intrinsic safety, the rule of the art, the guarantee figures, the DPR 462/01 Ministerial Decree 37/08, Legislative Decree 81/08 - Supplies: air, water, energy carriers, medical gases.
8. The hospital as a multi-risk work environment (I)
Risk description, European framework and Legislative Decree 81/08, assessment criteria: fire, explosion, electrical, mechanical, explosion risk
9. The hospital as a multi-risk work environment (II)
Risk description, European framework and Legislative Decree 81/08, assessment criteria: physical, chemical, biological risk - Risk from ionizing radiation in the workplace, Directive 2013/59 EURATOM
10. The European regulation on medical devices
EU regulation 2017/745 - Waiting for harmonized standards with the new regulation
11, Risk assessment in medical devices
The technical standard ISO 14971 - Use and safety features of the MD - In-depth study of the concept of risk applied to the MD - The standards of the ISO 110993 series and the evaluation of biocompatibility for the MD
12. Risk management and usability of medical devices
Electromedicals and the basic standard 60601 - Human factors, ergonomics, usability - Usage error - Examination of some safety notices reported by the Ministry of Health

Metodi didattici

Lectures (with the support of Powerpoint presentations) in which the theoretical and practical topics of the course are illustrated, with examples in particular of application on biomedical devices (duration: 34 hours).
Classroom exercises to exemplify the use of the theoretical tools (duration 4 hours), with the use of computer applications.
Group work with the use of role playing techniques (duration 4 hours).
Screening of films to illustrate the practical application of what was defined in the classroom (duration: 1 hour).
Visits to companies in the health sector can be made (duration: 3 hours).
One lesson will be dedicated to interventions - in the presence and / or remotely - of exponents of companies in the healthcare sector, former students employed in companies in the sector and authorities in the engineering, regulatory and certification sector (2 hours).
Real cases will also be examined that integrate various aspects of the course, with the possibility of extensive exposure as an exam.

Modalità di verifica dell'apprendimento

Knowledge assessment methods and criteria:
Learning of knowledge and skills is verified through an oral test of an average duration of 30 minutes. The level of learning is verified by putting the student three questions on theoretical arguments inherent in the course modules or the possibility of examining a real case (addressed in the classroom) which integrates the various aspects of the course.

Criteria for measuring learning and defining the final grade:
The final grade is expressed out of thirty.
Examination is passed if the score is greater than or equal to 18/30. Having properly studied all the topics dealt within the lesson and the use of proper and appropriate terminology guarantees a 24/30 vote. Greater votes are given to assessing the ability to adequately link the various topics covered in the different modules. At the discretion of the committee, it is praiseworthy the student who not only has studied all the subjects of the course but also demonstrates an uncommon ability to know the acquired knowledge and how to properly interconnect the subjects of the various modules. Conversely, the exam is not passed if the student has not properly studied at least one of the fundamental topics, reported as such by the lecturers during the course.
Degree thesis: possibility of choosing on risk assessment topics with internship at the Prevention and Protection Service of the Campus Biomedico Polyclinic.

Testi di riferimento

Teaching and didactic materials provided by the teachers. In addition, materials relating to the most significant doctrine and jurisprudential decisions and to the technical standards will be distributed.

Altre informazioni

- Knowledge and understanding: understanding of the international standards and rules for risk assessment and management, of the rules on the protection of personal data and of the applicable laws in the profession of biomedical engineer;
- Applying knowledge and understanding: ability to correctly estimate the risk in some common dangerous situations that may arise in the workplace and awareness of the problems and ways in which accidents occur;
- knowledge, understanding and application of national and EU regulations and best practices to minimize the risks associated with the management of personal data, particularly in the healthcare environment;
- understanding of the legal issues relating to the supply and use of medical devices, with particular reference to civil and penal liability in the context of contracts for the production of goods or the execution of services.
- Learning skills: personal deepening of topics reported by teachers and application of the concepts learned to specific areas;
- Making judgments: ability to analyze, synthesize and autonomy of judgment in the evaluation of the applicable sector regulations;
- Communication skills: ability to develop and expose, with clarity and language property, the interrelationships between the different multidisciplinary aspects.

L'attività didattica è offerta in:

Facoltà Dipartimentale di Ingegneria

Tipo corso	Corso di studio (Ordinamento)	Percorso	Crediti	S.S.D.
Corso di Laurea Magistrale	Master of Science in Biomedical Engineering (2019)	Common	6	ING-IND/33, ING-IND/33

Stampa del 07/05/2025