ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

REGOLAMENTO DIDATTICO DEL CORSO

LM-29 [INGEGNERIA ELETTRONICA]

Sede di Bologna

INDICE

Qualora, unicamente a scopo di sintesi, nel presente regolamento sia usata la sola forma maschile, questa è da intendersi riferita in maniera inclusiva a tutte le persone che operano nell'ambito della comunità stessa.

Art. 1 Requisiti per l'accesso al Corso

Conoscenze richieste per l'accesso

Per essere ammessi al corso di laurea magistrale in Ingegneria elettronica, occorre essere in possesso di una laurea, di un diploma universitario di durata triennale, o di altro titolo di studio conseguito all'estero, riconosciuto idoneo.

Occorre, altresì, il possesso dei seguenti requisiti curriculari:

1) essere in possesso di una laurea nelle classi
- ex D.M. 270: Classe L-8 - Ingegneria dell'Informazione
- ex D.M. 509/99: Classe 9 - Ingegneria dell'Informazione o corrispondenti titoli in ordinamenti previgenti

2) avere altresì acquisito crediti formativi universitari nei seguenti settori scientifico-disciplinari:
- SSD ING-INF/01 Elettronica (almeno 12 CFU)
- almeno 36 CFU globalmente nei tre gruppi di SSD di seguito elencati, con un minimo di 9 CFU in ciascun gruppo:
  - Gruppo 1: MAT/02 Algebra, MAT/03 Geometria, MAT/05 Analisi matematica, MAT/06 Probabilità e statistica matematica, MAT/07 Fisica matematica, MAT/08 Analisi numerica, MAT/09 Ricerca operativa;
  - Gruppo 2: CHIM/07 Fondamenti chimici delle tecnologie, FIS/01 Fisica sperimentale, FIS/03 Fisica della materia;
  - Gruppo 3: ING-INF/05 Sistemi di elaborazione delle informazioni, INF/01 Informatica.

Se il laureato proviene da un Ordinamento in cui non era in vigore il sistema dei CFU, le regole si applicano conteggiando un'annualità dell'Ordinamento di provenienza come equivalente a 12 CFU, e una semi-annualità come equivalente e 6 CFU.

È richiesta la conoscenza della lingua inglese di livello B2 del Quadro comune europeo di riferimento per la conoscenza delle lingue. La verifica è effettuata secondo le modalità definite nel punto Modalità di ammissione.

L'ammissione al corso di laurea magistrale è subordinata, inoltre, al superamento di una verifica dell'adeguatezza della personale preparazione che avverrà secondo le modalità definite nel punto Modalità di ammissione.

Modalità di ammissione

L'adeguatezza della personale preparazione si considera verificata per i candidati che rientrano **in almeno uno dei seguenti tre casi**.

1) Per i laureati ed i laureandi che hanno acquisito crediti formativi universitari nei seguenti settori scientifico-disciplinari:
- SSD ING-INF/01 Elettronica (almeno 15 CFU)
- SSD ING-INF/02 Campi elettromagnetici (almeno 6 CFU)
- SSD ING-INF/03 Telecomunicazioni (almeno 6 CFU)

I laureandi devono altresì avere acquisito almeno 150 CFU conseguiti tramite esami con voto.

Se il candidato proviene da un Ordinamento in cui non era in vigore il sistema dei CFU, le regole si applicano conteggiando un'annualità dell'Ordinamento di provenienza come equivalente a 12 CFU, e una semi-annualità come equivalente e 6 CFU.

2) Per i laureati che hanno ottenuto un voto di laurea maggiore o uguale a 95/110.

3) Per i laureandi che soddisfano entrambi i seguenti requisiti, che il candidato deve possedere secondo i termini e le modalità specificate nella Procedura di valutazione, redatta annualmente dagli Uffici competenti:
- almeno 150 CFU conseguiti tramite esami con voto;
- media ponderata maggiore o uguale a 25/30.

I criteri descritti in questo paragrafo si applicano anche a coloro che sono in possesso di un titolo di studio di livello universitario conseguito all'estero, giudicato idoneo dal Consiglio di Corso di Studio, per il quale siano possibili la conversione del voto di laurea secondo il sistema italiano, l'identificazione dei settori scientifico-disciplinari e il numero

di crediti conseguiti in ciascun settore. Se la conversione e/o l'identificazione non fossero possibili, il Consiglio di Corso di Studio procede alla valutazione della carriera sulla base della documentazione presentata dal candidato.

Per l'accesso al corso di studio è previsto l'accertamento delle conoscenze e competenze nella lingua inglese di livello B2 da dimostrare mediante certificazione linguistica secondo le modalità rese note tramite pubblicazione sul portale di Ateneo.

Nel caso di mancato superamento della verifica è preclusa l'iscrizione al corso.

Art. 2 Regole di mobilità fra i curricula del Corso di Studio

Il corso di studio è articolato in curricula. Lo studente può effettuare le scelte indicate nel piano didattico, con le modalità indicate nel piano stesso e nei termini resi noti tramite il Portale di Ateneo. È consentito il passaggio tra i curricula previsti entro i termini resi noti tramite il Portale di Ateneo.

At. 3 Piani di studio individuali

È prevista la possibilità di presentazione di piani di studio individuali con le modalità, i criteri e i termini resi noti tramite il Portale di Ateneo.
I piani di studio individuali, approvati dal Consiglio di corso di studi, non possono comunque prescindere dal rispetto dell'ordinamento e delle linee guida definite dagli Organi competenti.
Qualora il piano di studio preveda la scelta di attività formative attivate presso corsi di studio a numero programmato, l'ammissione alle stesse deve essere previamente approvata anche dal Consiglio di corso di studio a numero programmato sulla base di criteri da questo preventivamente individuati.

Art. 4 Modalità di svolgimento di ciascuna attività formativa e tipologia delle forme didattiche

Il piano didattico allegato indica le modalità di svolgimento delle attività formative e la relativa suddivisione in ore di didattica frontale, di esercitazioni pratiche o di tirocinio, nonché la tipologia delle forme didattiche.
Eventuali ulteriori informazioni in merito saranno rese note annualmente sul Portale di Ateneo.

Art. 5 Percorso flessibile

Lo studente può optare per il percorso flessibile che consente di completare il corso di studio in un tempo superiore o inferiore alla durata normale secondo le modalità definite nel Regolamento Didattico di Ateneo. Le attività formative previste dal percorso di studio, in caso di necessaria disattivazione, potranno essere sostituite, per garantire la qualità e la sostenibilità dell'offerta didattica.

Art. 6 Prove di verifica delle attività formative

Il piano didattico allegato prevede i casi in cui le attività formative si concludono con un esame con votazione in trentesimi ovvero con un giudizio di idoneità.
Le modalità di svolgimento delle verifiche sono stabilite annualmente dal Consiglio di corso di studio in sede di presentazione della programmazione didattica e rese note agli studenti prima dell'inizio delle lezioni tramite il Portale di Ateneo.

Art. 7 Attività formative a scelta dallo studente

L'indicazione da parte dello studente di attività formative a scelta guidata o a scelta autonoma deve essere presentata entro termini e secondo modalità deliberati annualmente e resi noti tramite il Portale.
Per quanto riguarda le attività formative a scelta autonoma, lo studente può effettuare, tra tutte le attività attivate o riconosciute dall'Ateneo, anche scelte diverse da quelle consigliate, purché coerenti con gli obiettivi formativi del Corso di Studi. In questo caso la sua richiesta verrà inoltrata al Consiglio di Corso di Studio, che valuta la coerenza della scelta con il percorso formativo dello studente.
La richiesta di variazione di insegnamenti a scelta autonoma, purché fatta entro i termini e nell'ambito delle scelte consigliate, non richiede approvazione da parte del Consiglio di Corso di Studio.

Art. 8 Criteri di riconoscimento dei crediti acquisiti in Corsi di Studio della stessa classe

Il riconoscimento dei crediti nella carriera degli studenti persegue il fine della mobilità degli studenti stessi ed è deliberato dal Consiglio di Corso di Studio, fino a concorrenza dei crediti dello stesso settore scientifico disciplinare previsti dall'ordinamento didattico del Corso di Studio, nel rispetto dei relativi ambiti scientifico disciplinari e della tipologia delle attività formative.
Per quanto riguarda il curriculum internazionale "E-BIT", il riconoscimento di crediti si riferisce ad attività formative erogate in lingua inglese.

Qualora, effettuati i riconoscimenti in base alle norme del presente Regolamento, restino crediti non utilizzati, il Consiglio di Corso di Studio può riconoscerli valutando il caso concreto sulla base delle affinità didattiche e culturali.

Art 9 Criteri di riconoscimento dei crediti acquisiti in Corsi di Studio di diversa classe, presso università telematiche e in Università estere

I crediti formativi universitari acquisiti sono riconosciuti dal Consiglio di Corso di Studio sulla base dei seguenti criteri:
- Analisi del programma svolto
- Numero complessivo di ore di didattica svolte
- Valutazione della congruità dei settori scientifico disciplinari (o, in mancanza di questi, delle discipline) e dei contenuti delle attività formative in cui lo studente ha maturato i crediti con gli obiettivi formativi specifici del corso di studio e delle singole attività formative da riconoscere, perseguendo comunque la finalità di mobilità degli studenti.

Il riconoscimento è effettuato fino a concorrenza dei crediti formativi universitari previsti dall'ordinamento didattico del Corso di Studio.
Per quanto riguarda il curriculum internazionale, il riconoscimento di crediti si riferisce ad attività formative erogate in lingua inglese.
Qualora, effettuati i riconoscimenti in base alle norme del presente regolamento, restino crediti non utilizzati, il Consiglio di Corso di Studio può riconoscerli valutando il caso concreto sulla base delle affinità didattiche e culturali.

Art. 10 Criteri di riconoscimento delle conoscenze e abilità extrauniversitarie

Possono essere riconosciute competenze acquisite fuori dall'Università nei casi previsti dalla normativa vigente. La richiesta di riconoscimento sarà valutata dal Consiglio di corso di studio tenendo conto del numero massimo di crediti riconoscibili fissato nell'ordinamento didattico del corso.
Il riconoscimento potrà avvenire qualora l'attività sia ritenuta coerente con gli obiettivi formativi specifici del corso di studio.

Art. 11 Tirocinio curriculare

Il Corso di Studio, su richiesta dello studente, può consentire, con le procedure stabilite dal Regolamento tirocini vigente o dai programmi internazionali di mobilità per tirocinio, e in conformità alle norme comunitarie, lo svolgimento di un tirocinio finalizzato alla preparazione della tesi di laurea o comunque collegato ad un progetto formativo mirato ad affinare il suo processo di apprendimento e formazione.

Art. 12 Prova finale

Caratteristiche della prova finale
La prova finale di laurea per il conseguimento della laurea magistrale consiste nella redazione e nella discussione pubblica di una tesi scritta ed elaborata in modo originale dallo studente, sotto la guida di un relatore, su un argomento coerente con gli obiettivi del corso di studio, che dimostri la padronanza degli argomenti sul piano teorico e applicativo, la capacità di operare in modo autonomo e capacità di comunicazione.

Modalità di svolgimento della prova finale
I contenuti della prova finale sono quelli della tesi di Laurea Magistrale, consistente in un'importante attività di progettazione o di ricerca svolta dallo studente su un argomento scelto dallo stesso. Questa attività si conclude con un elaborato con contenuti originali, redatto dallo studente sull'argomento della tesi e discusso davanti ad una Commissione nominata dal Consiglio di Corso di Studio.
L'argomento della relazione è svolto sotto la supervisione di un Docente di attività formative previste nella programmazione didattica dell'Ateneo.
Per l'ammissione alla prova finale lo studente deve avere conseguito tutti i crediti formativi previsti dall'Ordinamento didattico per le attività diverse dalla prova finale, distribuiti nei diversi tipi secondo le indicazioni del Regolamento.
Il voto di Laurea Magistrale è espresso in centodecimi. Il conferimento della lode richiede il giudizio unanime della Commissione esaminatrice.

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La Commissione Paritetica docenti-studenti ha espresso parere favorevole sulla coerenza dei crediti assegnati alle singole attività formative e gli specifici obiettivi formativi programmati, ai sensi dell'articolo 12 comma 3 del DM 270/04.

DEGREE PROGRAMME TEACHING REGULATIONS

Article 1. Entrance Requirements

Entrance to this Programme is granted to applicants that comply first with the curriculum requirements, and second with the necessary prior preparation. If the curriculum requirements are not complied with, access to the Programme is denied. If the curriculum requirements are satisfied, the applicant's prior preparation is checked.

Curriculum Requirements

Admission to the Programme is reserved to:

1) Applicants graduated from Italian First-cycle Degrees ("Lauree") of the "Ingegneria dell'Informazione" area (classe 9 defined in DM 509/99 or classe L-8 defined in DM 270/04);

2) They should have gained credits (CFU) in the following fields (SSD) as well:

- SSD ING-INF/01 Elettronica (at least 12 CFU)
- At least 36 CFU overall in the three following groups, with a minimum of 9 CFU in each of them:
  - Group 1: MAT/02 Algebra, MAT/03 Geometria, MAT/05 Analisi matematica, MAT/06 Probabilità e statistica matematica, MAT/07 Fisica matematica, MAT/08 Analisi numerica, MAT/09 Ricerca operativa;
  - Group 2: CHIM/07 Fondamenti chimici delle tecnologie, FIS/01 Fisica sperimentale, FIS/03 Fisica della materia;
  - Group 3: ING-INF/05 Sistemi di elaborazione delle informazioni, INF/01 Informatica.

Assessment of adequacy of the applicant's prior preparation

Requirements are satisfied by applicants meeting **at least one of the following three cases.**

1) Graduates and graduating students having gained credits (CFU) in the following fields (SSD):

- SSD ING-INF/01 Elettronica (at least 15 CFU)
- SSD ING-INF/02 Campi elettromagnetici (at least 6 CFU)
- SSD ING-INF/03 Telecomunicazioni (at least 6 CFU)

Graduating students should have registered at least 150 CFU with mark on their career.

2) Graduates with a graduation mark no lower than 95 out of 110

3) Graduating students meeting both the following conditions, to be checked according to the deadlines and rules made available each year by the University:

- having registered at least 150 CFU with mark on their career
- CGPA no lower than 25 out of 30.

The aforementioned criteria shall be applied to those holding a foreign degree for which it is possible to convert the CGPA into the Italian 110-scale as well as identifying scientific areas and credits (comparable to ECTS). Otherwise, the Degree Board shall assess the applicant's career.

Concerning language skills, the adequacy of prior preparation for admission to the Programme also includes knowledge of English of B-2 level or higher (according to the CEFR). The verification is deemed to be satisfied for students with appropriate language certification (such as TOEFL, IELTS, FCE, Cambridge Esol).

If the above-mentioned conditions are not met, the adequacy of the prior preparation is considered not satisfied.

Art. 2 Changing curriculum within the degree

It is allowed to make a request to change curriculum within the degree, following the procedure published on the University's website: such a request will be evaluated by the Degree Board against the same criteria set forth for individual study plans on the following Art. 3.

Art. 3 Individual study plans

There is the possibility of submitting individual study plans with the methods, criteria and deadlines disclosed through the University Portal.
The individual study plans, approved by the Degree Programme Board, must comply with the regulations and guidelines defined by competent bodies.
If the study plan includes learning activities activated in a degree programme with restricted access, admission to them must also be previously approved by the restricted access degree programme Board on the basis of criteria previously identified by it.

Art. 4 Teaching methods

The attached Study Plan reports the type and teaching methods for the various learning activities and the indications of class hours, exercises or traineeship. Additional information will be made available yearly on the website.

Art. 5 Course Attendance — Specified order of the exams

A student is not entitled to access an exam if the teaching activity does not appear in his/her study plan. Also, a student is not entitled to access an exam registered for a specific Academic Year, if the lessons of such a course in the same Academic Year have not been completed yet.
For the teaching activities held at CLA – Centro Linguistico di Ateneo, the attendance rules are specified by CLA. The exams of some courses must be undertaken in a specified order. Such cases, if any, are indicated in the Study Plan.

Art. 6 Flexible pathway

Students may opt for the flexible pathway that allows them to complete the Degree Programme in a shorter or longer time than the normal duration in accordance with the procedures defined in the University's Educational Regulations.
The educational activities envisaged by the study pathway may be replaced in the event of necessary deactivation, in order to guarantee the quality and sustainability of the educational offer.

Art. 7 Structure and outcome of the exams

Each teaching activity may have different types of final exam, e.g.:
- written and oral exam, with evaluation by a numerical rating (MARK)
- oral-only exam, with evaluation by numerical rating (MARK)
- written-only exam, with evaluation by numerical rating (MARK)
- any of the above, with evaluation by “passed/not passed” (PASS/FAIL).

For each teaching activity the outcome of the exam (MARK or PASS/FAIL) is indicated in the Study Plan.
The structure of the exam is proposed by the teacher and approved by the Degree Board or by the Board's Chairman if the latter is so entrusted by the Board. The exam is personal and aims at determining the intellectual maturity of the student along with his/her holding the knowledge and abilities typical of the course subject. Intermediate exams on the course subject are allowed, whose possible negative result does not influence the student’s access to the final exam. For the oral-only exams, a preliminary written exam is anyhow allowed, whose outcome influences the student’s access to the oral exam.
For teaching activities held at CLA, the structure and outcome of the exam are specified by CLA.

Art. 8 Electives Courses freely chosen by the student

The choice of the courses of D type (open elective courses as defined in the Study Plan) and the choice of the courses of B, C and F type that are not mandatory (elective courses as defined in the Study Plan) are made according to the rules defined by the University and published on the website. The deadline for the submission of such choices is decided yearly and made public through the University Portal.
The student is entitled to choose courses different from those suggested in the Study Plan. In this case his/her request will be forwarded to the Degree Board, which shall check the coherence of the choices with the Programme.
Requests to change open elective courses, presented within the prescribed terms and concerning suggested or recommended learning activities, do not need approval by the Degree Board.

Art. 9 Acknowledgement of credits acquired in programs belonging to the same class

This article applies only to Students owning an Italian Second-cycle Degree conforming to the provisions of the DM 270/2004 (“Laurea Magistrale”) belonging to the LM-29 class.
The acknowledgement is carried out according to the rules stated in Art. 9 of the Italian version of this document.

Art. 10 Acknowledgement of credits acquired in programs belonging to a different class, in e-learning programs and in international programs

Such acquired credits may be acknowledged by the Degree Board after an analysis based on the following criteria:

- contents of the course whence credits have been acquired
- total number of teaching hours of the course
- evaluation of the consistency of the scientific areas (SSD) or of the subjects (if the sectors are not defined) and of the contents of the courses whence the Student has acquired the credits with the specific teaching objective of the Programme, as indicated in the document entitled “Ordinamento didattico del Corso di Studio“.

Art. 11 Acknowledgement of competencies and abilities not acquired in university programs

Extra-university competencies might be recognized in the following cases:

- professional skills certified according to the relevant law;
- higher education skills designed and carried out in collaboration with the university.

Such a recognition will be evaluated by the Degree Board taking into account the determinations of the Academic Governance Bodies and the maximum number of credits set forth in the Degree Teaching Regulation.
The activity may be recognized provided it is deemed consistent with the Programme learning outcomes, taking into consideration the contents and the length in terms of hours of the said activity.

Art. 12 Internships

At the Student's request, the Degree Board may allow, with the procedures established by the running Internship Regulation or by international agreement for internship mobility and in compliance with EU rules, to pursue an internship in preparation of his/her final thesis/dissertation or to improve his/her learning and training process through an educational project.
These learning experiences must not exceed 6 months and must be completed before the date of dissertation. Credits can be allocated to them:
- as part of the credits assigned to the thesis/dissertation
- for internship activities provided by the Study Plan
- for elective learning activities which can be set also as internship
- for additional activities whose credits will exceed those necessary to achieve the degree.

Art. 13 Final exam

The contents of the final exam are those of the Thesis of a second-level University degree (“Laurea Magistrale”) and consist of a significant project or research activity carried out by the Student on a subject chosen by himself/herself. This activity is completed with a written document with original contents prepared by the Student on the Thesis subject and discussed in front of a Commission appointed by the Programme Board. In the final discussion the Student must demonstrate his/her mastering the subject, the ability to operate autonomously and to communicate effectively.
For accessing the final exam the Student must have acquired all the credits indicated by the document entitled “Ordinamento didattico del Corso di Studio” for the teaching activities different from the final exam and distributed in the different types as indicated in the Study Plan.
The final project is carried out under the supervision of a lecturer in charge of teaching activities included in the University teaching planning.
The outcome of the final exam is by a numerical rating and is expressed as a fraction of the form n/110, where n must not exceed 110. The unanimous agreement of the Commission is mandatory for attributing the evaluation 110/110 cum laude.

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The Faculty-student Joint Committee has agreed on the coherence between credits related to teaching activities and their learning outcomes, according to DM 270/2004 (article 3, subsection 3).

Anno Accademico **2026/2027**
Classe **LM-29-INGEGNERIA ELETTRONICA**
Corso **6716-INGEGNERIA ELETTRONICA**

Curriculum: CURRICULUM ELECTRONICS FOR INTELLIGENT SYSTEMS, BIG-DATA AND INTERNET OF THINGS (B70)

Primo Anno di Corso

Gruppo: 1) Mandatory courses

TAF: **Ambito:**

Cfu min: **Cfu max:**
Note:

Attività formativa	TIP	SSD	SSD 2024	TAF	CFU	ORE F/E/L/N	FREQ.	VER.
6716 000 000 93392 - 0 - ANALOG CIRCUITS AND SENSOR SYSTEMS M		ING-INF/01	IINF-01/A	B	9	90/0/0/0	No	Voto

Ambito: 211 - Ingegneria elettronica

Obiettivi: Fundamentals of analog interface design: how to bridge the physical and digital worlds. Application examples will include signal conditioning systems for pressure, temperature and optical sensors. Detailed contents: Operational amplifiers and review of basic linear op-amp circuits, Voltage/current references, Instrumentation Amplifiers, I/V and V/I conversion, charge amplifiers, Active Filters, Noise in analog circuits, A/D and D/A converters, Signal integrity, EMI/EMC.

Obiettivi inglese: Fundamentals of analog interface design: how to bridge the physical and digital worlds. Application examples will include signal conditioning systems for pressure, temperature and optical sensors. Detailed contents: Operational amplifiers and review of basic linear op-amp circuits, Voltage/current references, Instrumentation Amplifiers, I/V and V/I conversion, charge amplifiers, Active Filters, Noise in analog circuits, A/D and D/A converters, Signal integrity, EMI/EMC.

6716 000 000 93390 - 0 - DIGITAL SYSTEMS AND INTRODUCTION TO COMPUTER ARCHITECTURES M		ING-INF/01	IINF-01/A	B	9	90/0/0/0	No	Voto

Ambito: 211 - Ingegneria elettronica

Obiettivi: Provide a vision of digital circuits at transistor and gate level so as to have clear ideas about the main factors determining circuit performance, power consumption, signal integrity digital throughput. Overview of digital circuits at logic and register transfer level. Overview of microprocessor and memory architectures. Basics of testing, performance and power consumption at system level.

Obiettivi inglese: Provide a vision of digital circuits at transistor and gate level so as to have clear ideas about the main factors determining circuit performance, power consumption, signal integrity digital throughput. Overview of digital circuits at logic and register transfer level. Overview of microprocessor and memory architectures. Basics of testing, performance and power consumption at system level.

6716 000 000 93393 - 0 - ELECTRONIC FRONTIERS M			3	30/0/0/0	No	Giudizio

Ambito: F

Obiettivi: The course will address challenges in emerging technologies and architectures for intelligent systems, big data and internet of things, possibly changing year to year.

Obiettivi inglese: The course will address challenges in emerging technologies and architectures for intelligent systems, big data and internet of things, possibly changing year to year.

6716 000 000 29161 - 0 - MATHEMATICAL METHODS M	MAT/05	MATH-03/A	6	60/0/0/0	No	Voto

Ambito: 1144 - Attivita' formative affini o integrative C

Obiettivi: To know and to be able to use some mathematical techniques for the information engineering. Competencies: to know the theory of linear differential equations and systems; to be able to solve constant coefficient linear differential equations and systems; to know the Laplace transform and its use in solving linear differential equations; to have a basic knowledge of dynamical systems. Detailed contents: linear ordinary differential equations, Cauchy problem, existence and uniqueness of solutions. First-order linear equations. Discussion of existence and uniqueness of solutions of first-order differential equations and applications. Higher-order linear differential equations. Numerical solutions of differential equations. Introduction to nonlinear systems.
Laplace transform: definition, convergence abscissa; formal properties of the Laplace transform; Laplace transforms of standard functions. Step functions and their transforms. Laplace transforms of some further special functions: the saw-tooth function, the Dirac delta. Applications of Laplace transform to ordinary differential equations: theory and application in solving simple ordinary differential equations with constant coefficients and given boundary conditions.
Basic facts about linear transformations; eigenvalues, eigenvectors. Systems of linear differential equations; matrix exponential; dynamical systems, stability; numerical solutions of differential equations. General form of solutions. Transfer function. Stabilization problem.

Obiettivi inglese: To know and to be able to use some mathematical techniques for the information engineering. Competencies: to know the theory of linear differential equations and systems; to be able to solve constant coefficient linear differential equations and systems; to know the Laplace transform and its use in solving linear differential equations; to have a basic knowledge of dynamical systems. Detailed contents: linear ordinary differential equations, Cauchy problem, existence and uniqueness of solutions. First-order linear equations. Discussion of existence and uniqueness of solutions of first-order differential equations and applications. Higher-order linear differential equations. Numerical solutions of differential equations. Introduction to nonlinear systems.
Laplace transform: definition, convergence abscissa; formal properties of the Laplace transform; Laplace transforms of standard functions. Step functions and their transforms. Laplace transforms of some further special functions: the saw-tooth function, the Dirac delta. Applications of Laplace transform to ordinary differential equations: theory and application in solving simple ordinary differential equations with constant coefficients and given boundary conditions.
Basic facts about linear transformations; eigenvalues, eigenvectors. Systems of linear differential equations; matrix exponential; dynamical systems, stability; numerical solutions of differential equations. General form of solutions. Transfer function. Stabilization problem.

6716 000 000 93395 - 0 - RELIABLE DATA PROCESSING AND STORAGE FOR INTELLIGENT SYSTEMS M	ING-INF/01	IINF-01/A	6	60/0/0/0	No	Voto

Ambito: 211 - Ingegneria elettronica B

Obiettivi: Students will learn how to address the various issues related to the design of reliable data processing and storage for intelligent systems. These will range from evaluating the faults and aging phenomena that could occur during their fabrication and/or in-field operation, to analyzing the effects of such faults and aging phenomena and evaluating the related risks for the intelligent system intended operation, to designing them and their component blocks to guarantee robustness and/or tolerance of likely to occur faults and aging phenomena.

Obiettivi inglese: Students will learn how to address the various issues related to the design of reliable data processing and storage for intelligent systems. These will range from evaluating the faults and aging phenomena that could occur during their fabrication and/or in-field operation, to analyzing the effects of such faults and aging phenomena and evaluating the related risks for the intelligent system intended operation, to designing them and their component blocks to guarantee robustness and/or tolerance of likely to occur faults and aging phenomena.

6716 000 000 93391 - 0 - SEMICONDUCTOR DEVICES AND QUANTUM-COMPUTING M	ING-INF/01	IINF-01/A	9	90/0/0/0	No	Voto

Ambito: 211 - Ingegneria elettronica B

Obiettivi: Knowledge about the fundamentals of band theory of solids; knowledge about the physical phenomena underlying the transport of charged carriers in solids and about the basic semiconductor devices and solid-state memories. Illustration of the functioning principles of the most important categories of solid-state sensors. Sensors realized with process techniques used in Microelectronics and Micro-Electro-Mechanics Systems (MEMS). Application of the quantum theory to few-particle systems. Qbit as the elementary unit of quantum information. Example of solid-state devices where quantum effects play a dominant role. Physical feasibility of a computing device architecture based upon quantum dots and/or quantum wires.

Obiettivi inglese: Knowledge about the fundamentals of band theory of solids; knowledge about the physical phenomena underlying the transport of charged carriers in solids and about the basic semiconductor devices and solid-state memories. Illustration of the functioning principles of the most important categories of solid-state sensors. Sensors realized with process techniques used in Microelectronics and Micro-Electro-Mechanics Systems (MEMS). Application of the quantum theory to few-particle systems. Qbit as the elementary unit of quantum information. Example of solid-state devices where quantum effects play a dominant role. Physical feasibility of a computing device architecture based upon quantum dots and/or quantum wires.

6716 000 000 B8310 - 0 - STATISTICS AND MACHINE LEARNING FOR SIGNAL PROCESSING M	ING-INF/01	IINF-01/A		6	60/0/0/0	No	Voto

Ambito: 211 - Ingegneria elettronica B

Obiettivi: The course aims to give students the appropriate techniques for the acquisition and processing of real world data and the implementation of efficient and robust signal processing structures. Knowledge about the modern theory and practice of sampling from an engineering perspective, and classical and modern signal processing tools will be acquired.

Obiettivi inglese: The course aims to give students the appropriate techniques for the acquisition and processing of real world data and the implementation of efficient and robust signal processing structures. Knowledge about the modern theory and practice of sampling from an engineering perspective, and classical and modern signal processing tools will be acquired.

Gruppo: 2) Elective courses (First group)

TAF: B Ambito: 211 - Ingegneria elettronica

Cfu min: 6 Cfu max: 6

Note: Choose 6 credits among the following courses:

Attività formativa	TIP	SSD	SSD 2024	TAF	CFU	ORE F/E/L/N	FREQ.	VER.
6716 000 000 84442 - 0 - HIGH FREQUENCY ELECTRONIC CIRCUITS M		ING-INF/01	IINF-01/A		6	60/0/0/0	No	Voto

Ambito: 211 - Ingegneria elettronica B

Obiettivi: The course deals with the analysis and design of high-frequency electronic circuits as those found in IoT, 5G and remote sensing applications. Students learn how high-frequency front-ends work, to state and evaluate the specifications of the main building blocks and to face the trade-offs involved in their design.

Obiettivi inglese: The course deals with the analysis and design of high-frequency electronic circuits as those found in IoT, 5G and remote sensing applications. Students learn how high-frequency front-ends work, to state and evaluate the specifications of the main building blocks and to face the trade-offs involved in their design.

6716 000 000 B8311 - 0 - SECURITY OF DATA AND NEURAL PROCESSING M	ING-INF/01	IINF-01/A		6	60/0/0/0	No	Voto

Ambito: B

Obiettivi: The course provides a basic knowledge of the fundamental concepts, terminology and problems in cryptography as well as tools for assessing the security of data protection schemes commonly employed. It also provides high level requirements and design guidelines for typical blocks used in security-ensuring mechanisms.

Obiettivi inglese: The course provides a basic knowledge of the fundamental concepts, terminology and problems in cryptography as well as tools for assessing the security of data protection schemes commonly employed.
It also provides high level requirements and design guidelines for typical blocks used in security-ensuring mechanisms.

Gruppo: 3) Elective courses (Second group)

TAF: C Ambito: 1144 - Attivita' formative affini o integrative

Cfu min: 6 Cfu max: 6

Note: Choose 6 credits among the following courses:

Attività formativa	TIP	SSD	SSD 2024	TAF	CFU	ORE F/E/L/N	FREQ.	VER.
6716 000 000 B5224 - 0 - ARTIFICIAL INTELLIGENCE FOR MEDICINE M		ING-INF/06	IBIO-01/A		6	60/0/0/0	No	Voto

Ambito: 1144 - Attivita' formative affini o integrative C

Obiettivi: At the end of the course, the student has:
-knowledge regarding the need for AI in Medicine;
-understanding of weaknesses of AI techniques, methods to overcome the challenges of AI in Medicine, and ways in which AI may improve healthcare;
-essential knowledge to develop and implement reliable AI solutions in clinical research (using, e.g., supervised and unsupervised machine and deep learning techniques, explainable AI methods, and generative adversarial techniques);
-practical skills to develop state-of-the-art AI tools with real-world medical data (e.g., clinical and imaging data);
-the ability to critically read, discuss and evaluate methods and results of studies using AI in Medicine;
-an overview of state-of-the-art AI-powered tools in Medicine.

Obiettivi inglese: At the end of the course, the student has:
-knowledge regarding the need for AI in Medicine;
-understanding of weaknesses of AI techniques, methods to overcome the challenges of AI in Medicine, and ways in which AI may improve healthcare;
-essential knowledge to develop and implement reliable AI solutions in clinical research (using, e.g., supervised and unsupervised machine and deep learning techniques, explainable AI methods, and generative adversarial techniques);
-practical skills to develop state-of-the-art AI tools with real-world medical data (e.g., clinical and imaging data);
-the ability to critically read, discuss and evaluate methods and results of studies using AI in Medicine;
-an overview of state-of-the-art AI-powered tools in Medicine.

6716 000 000 99195 - 0 - CYBER-PHYSICAL SYSTEMS PROGRAMMING M	ING-INF/05	IINF-05/A	6	60/0/0/0	No	Voto

Ambito: 1144 - Attivita' formative affini o integrative C

Obiettivi: Il corso fornisce allo studente una conoscenza di base delle architetture software e gli ambienti di sviluppo, programmazione e progettazione di sistemi cyber-fisici, con particolare enfasi alla coesistenza di task di controllo, processing di data stream, e comunicazione IoT con requisiti di real-time e cybersecurity. Nel corso lo studente impara a utilizzare compilatori, librerie, runtime e middleware per piattaforme e architetture eterogenee, dotate di processori multicore, co-processori e acceleratori HW e SW per il processing di stream di dati da sensori e verso attuatori.

Obiettivi inglese: The course provides the student with a basic knowledge of software architectures as well as the development, programming and design environments for cyber-physical systems, with particular emphasis on the coexistence of control tasks, data stream processing, and IoT communication with real-time and cybersecurity requirements. The student will learn to use compilers, libraries, runtimes and middleware for heterogeneous platforms and architectures, equipped with multicore processors, co-processors and HW and SW accelerators for the processing of data streams from sensors and towards actuators.

6716 000 000 81683 - 0 - INTERNET OF THINGS	INF/01	INFO-01/A	6	48/0/0/0	No	Voto

Ambito: 1144 - Attivita' formative affini o integrative C

Obiettivi: Al termine dell'attività formativa, lo studente comprende le architetture e le metodologie alla base dell'Internet delle Cose (IoT) seguendo un approccio che pone al centro i dati. Lo studente ha una comprensione profonda dei protocolli di rete, dell'integrazione di dispositivi mobili e pervasivi, di piattaforme middleware per sistemi IoT M2M, di principi di computazione edge/distribuita/gateway, di nuovi servizi, di piattaforme di servizio e di scenari applicativi innovativi.

Obiettivi inglese: At the end of the course, the student understands the architectures and methodologies at the basis of the Internet of Things (IoT) following a data centric approach. The student has a deep understanding of network protocols, integration of mobile and pervasive end-devices, middleware platforms for M2M-based IoT systems, edge/distributed/gateway computing principles, new services, service platforms and innovative application scenarios.

6716 000 000 73548 - 0 - WIRELESS SENSOR NETWORKS M	ING-INF/03	IINF-03/A	6	60/0/0/0	No	Voto

Ambito: C

Obiettivi: This course introduces wireless communications for the Internet of Things (IoT). The course will describe the most used wireless technologies enabling the deployment of IoT networks. The theoretical part of the course will provide to students skills for designing an IoT network, accounting for connectivity, medium access control layer and routing issues, while considering the propagation environment where the network is located. Laboratory activities will allow students to use wireless devices to setup and run small IoT networks in a realistic environment and study their performance.

Obiettivi inglese: This course introduces wireless communications for the Internet of Things (IoT). The course will describe the most used wireless technologies enabling the deployment of IoT networks. The theoretical part of the course will provide to students skills for designing an IoT network, accounting for connectivity, medium access control layer and routing issues, while considering the propagation environment where the network is located. Laboratory activities will allow students to use wireless devices to setup and run small IoT networks in a realistic environment and study their performance.

Secondo Anno di Corso

Gruppo: 1) Mandatory courses

TAF: Ambito:

Cfu min: Cfu max:
Note:

Attività formativa	TIP	SSD	SSD 2024	TAF	CFU	ORE F/E/L/N	FREQ.	VER.

6716 000 000 B8312 - 0 - ALGORITHMS AND ARCHITECTURES FOR BIG DATA PROCESSING M	ING-INF/01	IINF-01/A		6	60/0/0/0	No	Voto

Ambito: 211 - Ingegneria elettronica B

Obiettivi: The course provides students with a basic knowledge of problems and corresponding techniques of solutions implied by the ever increasing amount and complexity of the data available for analyses and decisions, i.e., the so called Big-Data (BD). The corresponding issues are tackled by multiple points of view: from the abstract characterization of the mathematical properties of BD, to the hardware architectures needed to process them.

Obiettivi inglese: The course provides students with a basic knowledge of problems and corresponding techniques of solutions implied by the ever increasing amount and complexity of the data available for analyses and decisions, i.e., the so called Big-Data (BD). The corresponding issues are tackled by multiple points of view: from the abstract characterization of the mathematical properties of BD, to the hardware architectures needed to process them.

6716 000 000 93397 - 0 - HARDWARE SOFTWARE DESIGN OF AI AND IOT SYSTEMS M I.C				12			Voto
Modulo integrato: 93398 - ARCHITECTURES FOR ARTIFICIAL INTELLIGENCE M	ING-INF/01	IINF-01/A		6	60/0/0/0	No	

Ambito: 211 - Ingegneria elettronica B

Obiettivi: The main goal of the class is to enable students to specify, configure, program and verify complex embedded electronic systems for the Internet of Things and for Artificial Intelligence. The importance of hardware-software interaction will be emphasized, as all practical IoT and AI systems are programmable. The class will provide working knowledge on state-of-the-art hardware platforms used in embedded AI and IoT applications - spanning a wide range of power and cost vs. performance tradeoffs. A detailed coverage will be given of software abstractions and methodologies for developing applications leveraging the capabilities of the above mentioned platforms. Design automation tools and flows will also be covered.

Obiettivi inglese: The main goal of the class is to enable students to specify, configure, program and verify complex embedded electronic systems for the Internet of Things and for Artificial Intelligence. The importance of hardware-software interaction will be emphasized, as all practical IoT and AI systems are programmable. The class will provide working knowledge on state-of-the-art hardware platforms used in embedded AI and IoT applications - spanning a wide range of power and cost vs. performance tradeoffs. A detailed coverage will be given of software abstractions and methodologies for developing applications leveraging the capabilities of the above mentioned platforms. Design automation tools and flows will also be covered.

Modulo integrato: 93322 - HARDWARE-SOFTWARE DESIGN OF IOT SYSTEMS M	ING-INF/01	IINF-01/A		6	60/0/0/0	No	

Ambito: 211 - Ingegneria elettronica B

Obiettivi: L'obiettivo principale del corso è fornire metodologie per l'analisi e la programmazione di sistemi elettronici embedded single-core e multi-core. Viene sottolineata l'importanza dei componenti software in tutti i sistemi elettronici. Le principali conoscenze e competenze da conseguire sono (i) una chiara comprensione delle architetture hardware embedded programmabili più comuni e delle piattaforme hardware-software; (ii) metodologie per l'analisi comparativa e approcci per stimare gli indicatori chiave di prestazione (KPI) come costi, prestazioni, efficienza energetica, per valutare quantitativamente l'utilizzo di una piattaforma hardware-software per un dominio applicativo (ad esempio automobilistico, di consumo, industriale) e per un'applicazione specifica; (iii) tecniche di sviluppo e verifica del software embedded, tenendo conto dei vincoli tipici e degli indicatori chiave di prestazione che differenziano i sistemi embedded dai sistemi informatici generici; (iv) metodi e strumenti di ottimizzazione del software per hardware embedded sia single-core che multi-core.

Obiettivi inglese: The main goal of the class is to provide methodologies for analyzing and programming singe-core and multi-core embedded electronic systems. The importance of software components in virtually all electronic systems is emphasized. The key learning outcomes are (i) a clear understanding of the most common programmable embedded hardware architectures and hardware-software platforms; (ii) methodologies for comparative analysis and approaches to estimate key performance indicators (KPIs) such as cost, performance, energy efficiency, to quantitatively assess the matching of a hardware-software platform for an application domain (e.g. automotive, consumer, industrial) and for a specific application; (iii) embedded software development and verification techniques, taking into account typical constraints and performance KPIs that differentiate embedded systems from general-purpose computing systems; (iv) hardware-aware software optimization methods and tools for both single-core and multi-core embedded hardware.

Gruppo: 2) Final examination

TAF: Ambito:

Cfu min: 18 Cfu max: 18

Note: Students can choose only the "Final examination" (Group A) or the "Final examination" and one of the learning activities among "Internship for preparation for the final examination", "Internship abroad for preparation for the final examination" or "Preparation for the final examination abroad" (Group B).

Attività formativa	TIP	SSD	SSD 2024	TAF	CFU	ORE	F/E/L/N	FREQ.	VER.

2.1) Group A 0-18

6716 000 000 B0636 - 0 - FINAL EXAMINATION 18 0/0/0/0 No

Ambito: 1018 - Per la prova finale E

Obiettivi: Preparation for the final examination according to the provisions of the Teaching Regulation of the Program.

Obiettivi inglese: Preparation for the final examination according to the provisions of the Teaching Regulation of the Program.

2.2) Group B 0-18

6716 000 000 86298 - 0 - FINAL EXAMINATION 3 0/0/0/0 No

Ambito: 1018 - Per la prova finale E

Obiettivi: Preparation for the final examination according to the provisions of the Teaching Regulation of the Program.

Obiettivi inglese: Preparation for the final examination according to the provisions of the Teaching Regulation of the Program.

6716 000 000 90054 - 0 - INTERNSHIP ABROAD FOR PREPARATION OF THE FINAL EXAMINATION 15 0/0/375/0 No Giudizio

Ambito: 1018 - Per la prova finale E

Obiettivi: Promoting students' knowledge of the work field through thesis preparation abroad, based on a internship project agreed with the supervisor.

Obiettivi inglese: Promoting students' knowledge of the work field through thesis preparation abroad, based on a internship project agreed with the supervisor.

6716 000 000 90377 - 0 - INTERNSHIP FOR PREPARATION FOR THE FINAL EXAMINATION 15 0/0/375/0 No Giudizio

Ambito: 1018 - Per la prova finale E

Obiettivi: Promoting students' knowledge of the work field through thesis preparation, based on a internship project agreed with the supervisor.

Obiettivi inglese: Promoting students' knowledge of the work field through thesis preparation, based on a internship project agreed with the supervisor.

6716 000 000 90053 - 0 - PREPARATION FOR THE FINAL EXAMINATION ABROAD 15 0/0/375/0 No Giudizio

Ambito: 1018 - Per la prova finale E

Obiettivi: With the preparation for the final examination abroad, the students get a direct knowledge of the possible professional developments linked to the specific work and research field in line with master's programme.

Obiettivi inglese: With the preparation for the final examination abroad, the students get a direct knowledge of the possible professional developments linked to the specific work and research field in line with master's programme.

Gruppo: 3) Elective courses (First group)

TAF: C Ambito: 1144 - Attivita' formative affini o integrative

Cfu min: 6 Cfu max: 6

Note: Choose 6 credits among the following courses:

Attività formativa	TIP	SSD	SSD 2024	TAF	CFU	ORE F/E/L/N	FREQ.	VER.

6716 000 000 B8313 - 0 - BIG DATA FOR COMMUNICATIONS M	ING-INF/03	IINF-03/A	6	60/0/0/0	No	Voto

Ambito: C

Obiettivi: In the first part of the course students are introduced to the fundamental concepts of Big Data, machine learning, and neural networks. The course also covers key aspects of probability theory and graph theory, which provide the foundation for understanding probabilistic graphical models (e.g., Bayesian networks). These models are widely used in industrial applications, including information validation, fault isolation, and reliability analessi, all of which are becoming increasingly relevant in modern contexts.
The second part of the course focuses on more advanced topics in artificial intelligence, such as energy based models (e.g., Boltzmann machines). Students also gain practical experience in applying machine learning and other AI techniques to enhance the performance of communication systems by leveraging the vast amount of data available in contemporary wireless communication environments.

Obiettivi inglese: In the first part of the course students are introduced to the fundamental concepts of Big Data, machine learning, and neural networks. The course also covers key aspects of probability theory and graph theory, which provide the foundation for understanding probabilistic graphical models (e.g., Bayesian networks). These models are widely used in industrial applications, including information validation, fault isolation, and reliability analessi, all of which are becoming increasingly relevant in modern contexts.
The second part of the course focuses on more advanced topics in artificial intelligence, such as energy based models (e.g., Boltzmann machines). Students also gain practical experience in applying machine learning and other AI techniques to enhance the performance of communication systems by leveraging the vast amount of data available in contemporary wireless communication environments.

6716 000 000 91250 - 0 - DEEP LEARNING	INF/01	INFO-01/A	6	48/0/0/0	No	Voto

Ambito: 1144 - Attivita' formative affini o integrative C

Obiettivi: At the end of the course, the student understands the foundational ideas, recent advances and application potential of deep neural systems. The student understands supervised and unsupervised techniques, basic neural topologies, methods for visualizing and understanding the behavior on neural nets, adversarial and generative techniques, reinforcement learning, and recurrent networks. The student is able to apply such technologies to solving classification problems in realistic domains.

Obiettivi inglese: At the end of the course, the student understands the foundational ideas, recent advances and application potential of deep neural systems. The student understands supervised and unsupervised techniques, basic neural topologies, methods for visualizing and understanding the behavior on neural nets, adversarial and generative techniques, reinforcement learning, and recurrent networks. The student is able to apply such technologies to solving classification problems in realistic domains.

6716 000 000 95601 - 0 - OPTIMIZATION AND MACHINE LEARNING M	MAT/09	MATH-06/A	6	60/0/0/0	No	Voto

Ambito: 1144 - Attivita' formative affini o integrative C

Obiettivi: The aim of this course is to provide the student the ability of using both machine learning and mathematical optimization for advanced analytics. In particular, machine learning techniques are at the core of predictive analytics, where – based on historical data – one needs to predict the future outcome of a time series or classify unseen observations. Machine learning techniques build upon optimization techniques, and, in the case of neural networks, continuous optimization methods. Conversely, discrete optimization methods are at the core of prescriptive analytics, where one is required to make decisions optimizing a certain revenue / saving function by selecting within a discrete set. Discrete optimization methods are empowered by machine learning in estimating the parameters of the associated decision problems and, in some cases, benefit from machine learning to speed up the solution techniques.

Obiettivi inglese: The aim of this course is to provide the student the ability of using both machine learning and mathematical optimization for advanced analytics. In particular, machine learning techniques are at the core of predictive analytics, where – based on historical data – one needs to predict the future outcome of a time series or classify unseen observations. Machine learning techniques build upon optimization techniques, and, in the case of neural networks, continuous optimization methods. Conversely, discrete optimization methods are at the core of prescriptive analytics, where one is required to make decisions optimizing a certain revenue / saving function by selecting within a discrete set. Discrete optimization methods are empowered by machine learning in estimating the parameters of the associated decision problems and, in some cases, benefit from machine learning to speed up the solution techniques.

6716 000 000 69441 - 0 - OPTIMIZATION MODELS AND ALGORITHMS M	MAT/09	MATH-06/A	6	60/0/0/0	No	Voto

Ambito: 1144 - Attivita' formative affini o integrative C

Obiettivi: The goal of the course is to deal with Integer Programming that is a very powerful tool for modeling combinatorial optimization problems arising in many branches of engineering, industry and resource allocation. The first part of the course covers the modeling aspects of the field, providing the tools for constructing effective mathematical models, i.e., models that can be solved in practice. The second part is devoted to the algorithmic aspects: basic algorithms are reviewed and more sophisticated ones, useful for those models characterized by a large number of variables and/or constraints, are presented in detail. Finally, the third part of the course discusses real-world applications. At the end of the course students are able to formalize a combinatorial problem taken for the real life and run specific tools and algorithms for solving it in practice.

Obiettivi inglese: The goal of the course is to deal with Integer Programming that is a very powerful tool for modeling combinatorial optimization problems arising in many branches of engineering, industry and resource allocation. The first part of the course covers the modeling aspects of the field, providing the tools for constructing effective mathematical models, i.e., models that can be solved in practice. The second part is devoted to the algorithmic aspects: basic algorithms are reviewed and more sophisticated ones, useful for those models characterized by a large number of variables and/or constraints, are presented in detail. Finally, the third part of the course discusses real-world applications. At the end of the course students are able to formalize a combinatorial problem taken for the real life and run specific tools and algorithms for solving it in practice.

Gruppo: 4) Elective courses (Second group)

TAF: F Ambito: 0000 - Nessun Ambito

Cfu min: 6 Cfu max: 6
Note: Choose 6 credits among the following courses:

Attività formativa	TIP	SSD	SSD 2024	TAF	CFU	ORE F/E/L/N	FREQ.	VER.
6716 000 000 82091 - 0 - INTERNSHIP IN ICT M					6	0/0/150/0	No	Giudizio
Ambito:				F				
Obiettivi: Tirocinio in ICT soggetto ad approvazione da parte della Commissione Tirocini								
Obiettivi inglese: Internship in ICT to be approved by the Degree's Internship Committee								
6716 000 000 87195 - 0 - LAB OF BIG DATA ARCHITECTURES M					3	0/0/30/0	No	Giudizio
Ambito: 0000 - Nessun Ambito				F				
Obiettivi: The Lab of Big Data architectures extends and integrates what learnt by the student in the course statistics and architectures for big data processing with a more in depth and practical knowledge of the big-data technologies and architectures. The students will learn how to design a big data system, the key concepts and differentiators behind state-of-the-art technologies and architectures, and how to use it effectively. This will be done by a series of practical exercises with interactive explanations, where students will learn by solving practical problems and examples.								
Obiettivi inglese: The Lab of Big Data architectures extends and integrates what learnt by the student in the course statistics and architectures for big data processing with a more in depth and practical knowledge of the big-data technologies and architectures. The students will learn how to design a big data system, the key concepts and differentiators behind state-of-the-art technologies and architectures, and how to use it effectively. This will be done by a series of practical exercises with interactive explanations, where students will learn by solving practical problems and examples.								
6716 000 000 84419 - 0 - LAB OF DIGITAL ELECTRONICS M					3	30/0/0/0	No	Giudizio
Ambito:				F				
Obiettivi: Aim of this course is to enrich the practical experience of the students on advanced digital hardware design tools and methodologies. The students are expected to work on a practical project to deeper their knowledge in digital hardware design, integration of hardware modules into Systems on Chip, and prototyping of digital systems on FPGA devices. The course will also cover aspects related to interactions between software and hardware components in Systems on Chip.								
Obiettivi inglese: Aim of this course is to enrich the practical experience of the students on advanced digital hardware design tools and methodologies. The students are expected to work on a practical project to deeper their knowledge in digital hardware design, integration of hardware modules into Systems on Chip, and prototyping of digital systems on FPGA devices. The course will also cover aspects related to interactions between software and hardware components in Systems on Chip.								
6716 000 000 72972 - 0 - LAB OF HIGH-FREQUENCY CIRCUIT DESIGN M					3	0/0/30/0	No	Giudizio
Ambito: 0000 - Nessun Ambito				F				
Obiettivi: Learning the specific procedures for the analysis and the design of RF, microwave and modelling -wave circuits by using the most advanced CAD tools. Specific projects will be assigned to students. Each project will consist in the design of a typical RF or microwave circuit exploited in communication system front-ends (e.g. transmitters, receivers, transponders, transceivers) or in high-frequency remote sensor systems (e.g. radars, SARs, altimeters).								
Obiettivi inglese: Learning the specific procedures for the analysis and the design of RF, microwave and modelling -wave circuits by using the most advanced CAD tools. Specific projects will be assigned to students. Each project will consist in the design of a typical RF or microwave circuit exploited in communication system front-ends (e.g. transmitters, receivers, transponders, transceivers) or in high-frequency remote sensor systems (e.g. radars, SARs, altimeters).								

6716 000 000 93324 - 0 - LAB OF INTELLIGENT SENSOR SYSTEMS M		3	0/0/30/0	No	Giudizio

Ambito: F

Obiettivi: Compensation of amplifiers, opamp macromodels, high slew-rate opamp, instrumentation opamps, opamp characterization and non- idealities, noise in the opamps. Use of Spice as a circuit simulator.

Obiettivi inglese: Compensation of amplifiers, opamp macromodels, high slew-rate opamp, instrumentation opamps, opamp characterization and non- idealities, noise in the opamps. Use of Spice as a circuit simulator.

6716 000 000 93323 - 0 - LAB OF RELIABLE INTELLIGENT SYSTEMS M		3	0/0/30/0	No	Giudizio

Ambito: F

Obiettivi: Circuit level design and verification by electrical level and Monte Carlo simulations performed by the tool HSPICE. Circuit reliability analysis by electrical level simulations performed by the tool HSPICE. System integration and synthesis performed by the tool Synopsys Design Compiler. System reliability evaluation by fault injection and simulation performed by the tool Synopsys Tetramax. System implementation by Field Programmable Gate Arrays (FPGAs) performed by the Xilinx implementation tool.

Obiettivi inglese: Circuit level design and verification by electrical level and Monte Carlo simulations performed by the tool HSPICE. Circuit reliability analysis by electrical level simulations performed by the tool HSPICE. System integration and synthesis performed by the tool Synopsys Design Compiler. System reliability evaluation by fault injection and simulation performed by the tool Synopsys Tetramax. System implementation by Field Programmable Gate Arrays (FPGAs) performed by the Xilinx implementation tool.

Gruppo: 5) Courses freely chosen by the student

TAF: D Ambito: 1008 - A scelta dello studente

Cfu min: 12 Cfu max: 12

Note: Choose 12 credits. The course board suggests to attend to the following courses:

Attività formativa	TIP	SSD	SSD 2024	TAF	CFU	ORE F/E/L/N	FREQ.	VER.
6716 000 000 B5224 - 0 - ARTIFICIAL INTELLIGENCE FOR MEDICINE M		ING-INF/06	IBIO-01/A		6	60/0/0/0	No	Voto

Ambito: 1144 - Attivita' formative affini o integrative C

Obiettivi: At the end of the course, the student has:
-knowledge regarding the need for AI in Medicine;
-understanding of weaknesses of AI techniques, methods to overcome the challenges of AI in Medicine, and ways in which AI may improve healthcare;
-essential knowledge to develop and implement reliable AI solutions in clinical research (using, e.g., supervised and unsupervised machine and deep learning techniques, explainable AI methods, and generative adversarial techniques);
-practical skills to develop state-of-the-art AI tools with real-world medical data (e.g., clinical and imaging data);
-the ability to critically read, discuss and evaluate methods and results of studies using AI in Medicine;
-an overview of state-of-the-art AI-powered tools in Medicine.

Obiettivi inglese: At the end of the course, the student has:
-knowledge regarding the need for AI in Medicine;
-understanding of weaknesses of AI techniques, methods to overcome the challenges of AI in Medicine, and ways in which AI may improve healthcare;
-essential knowledge to develop and implement reliable AI solutions in clinical research (using, e.g., supervised and unsupervised machine and deep learning techniques, explainable AI methods, and generative adversarial techniques);
-practical skills to develop state-of-the-art AI tools with real-world medical data (e.g., clinical and imaging data);
-the ability to critically read, discuss and evaluate methods and results of studies using AI in Medicine;
-an overview of state-of-the-art AI-powered tools in Medicine.

6716 000 000 B8313 - 0 - BIG DATA FOR COMMUNICATIONS M	ING-INF/03	IINF-03/A	6	60/0/0/0	No	Voto

Ambito: C

Obiettivi: In the first part of the course students are introduced to the fundamental concepts of Big Data, machine learning, and neural networks. The course also covers key aspects of probability theory and graph theory, which provide the foundation for understanding probabilistic graphical models (e.g., Bayesian networks). These models are widely used in industrial applications, including information validation, fault isolation, and reliability analessi, all of which are becoming increasingly relevant in modern contexts.
The second part of the course focuses on more advanced topics in artificial intelligence, such as energy based models (e.g., Boltzmann machines). Students also gain practical experience in applying machine learning and other AI techniques to enhance the performance of communication systems by leveraging the vast amount of data available in contemporary wireless communication environments.

Obiettivi inglese: In the first part of the course students are introduced to the fundamental concepts of Big Data, machine learning, and neural networks. The course also covers key aspects of probability theory and graph theory, which provide the foundation for understanding probabilistic graphical models (e.g., Bayesian networks). These models are widely used in industrial applications, including information validation, fault isolation, and reliability analessi, all of which are becoming increasingly relevant in modern contexts.
The second part of the course focuses on more advanced topics in artificial intelligence, such as energy based models (e.g., Boltzmann machines). Students also gain practical experience in applying machine learning and other AI techniques to enhance the performance of communication systems by leveraging the vast amount of data available in contemporary wireless communication environments.

6716 000 000 99195 - 0 - CYBER-PHYSICAL SYSTEMS PROGRAMMING M	ING-INF/05	IINF-05/A	6	60/0/0/0	No	Voto

Ambito: 1144 - Attivita' formative affini o integrative C

Obiettivi: Il corso fornisce allo studente una conoscenza di base delle architetture software e gli ambienti di sviluppo, programmazione e progettazione di sistemi cyber-fisici, con particolare enfasi alla coesistenza di task di controllo, processing di data stream, e comunicazione IoT con requisiti di real-time e cybersecurity. Nel corso lo studente impara a utilizzare compilatori, librerie, runtime e middleware per piattaforme e architetture eterogenee, dotate di processori multicore, co-processori e acceleratori HW e SW per il processing di stream di dati da sensori e verso attuatori.

Obiettivi inglese: The course provides the student with a basic knowledge of software architectures as well as the development, programming and design environments for cyber-physical systems, with particular emphasis on the coexistence of control tasks, data stream processing, and IoT communication with real-time and cybersecurity requirements. The student will learn to use compilers, libraries, runtimes and middleware for heterogeneous platforms and architectures, equipped with multicore processors, co-processors and HW and SW accelerators for the processing of data streams from sensors and towards actuators.

6716 000 000 91250 - 0 - DEEP LEARNING	INF/01	INFO-01/A	6	48/0/0/0	No	Voto

Ambito: 1144 - Attivita' formative affini o integrative C

Obiettivi: At the end of the course, the student understands the foundational ideas, recent advances and application potential of deep neural systems. The student understands supervised and unsupervised techniques, basic neural topologies, methods for visualizing and understanding the behavior on neural nets, adversarial and generative techniques, reinforcement learning, and recurrent networks. The student is able to apply such technologies to solving classification problems in realistic domains.

Obiettivi inglese: At the end of the course, the student understands the foundational ideas, recent advances and application potential of deep neural systems. The student understands supervised and unsupervised techniques, basic neural topologies, methods for visualizing and understanding the behavior on neural nets, adversarial and generative techniques, reinforcement learning, and recurrent networks. The student is able to apply such technologies to solving classification problems in realistic domains.

6716 000 000 87236 - 0 - ELECTRIC POWER SYSTEMS M	ING-IND/33	IIND-08/B	6	60/0/0/0	No	Voto

Ambito: 1008 - A scelta dello studente D

Obiettivi: The course provides the basics for understanding the main aspects of modern power systems/smart grids analysis and operation in steady state and transient/dynamic conditions. At the end of the course students are able to understand the main technical problems relevant to transmission and distribution of electric energy, and can solve them with particular reference to load flow, short circuit calculation, stability, frequency control, voltage control and renewable sources diffusion in the electric network and smart grids.

Obiettivi inglese: The course provides the basics for understanding the main aspects of modern power systems/smart grids analysis and operation in steady state and transient/dynamic conditions. At the end of the course students are able to understand the main technical problems relevant to transmission and distribution of electric energy, and can solve them with particular reference to load flow, short circuit calculation, stability, frequency control, voltage control and renewable sources diffusion in the electric network and smart grids.

6716 000 000 84442 - 0 - HIGH FREQUENCY ELECTRONIC CIRCUITS M	ING-INF/01	IINF-01/A	6	60/0/0/0	No	Voto

Ambito: 211 - Ingegneria elettronica B

Obiettivi: The course deals with the analysis and design of high-frequency electronic circuits as those found in IoT, 5G and remote sensing applications. Students learn how high-frequency front-ends work, to state and evaluate the specifications of the main building blocks and to face the trade-offs involved in their design.

Obiettivi inglese: The course deals with the analysis and design of high-frequency electronic circuits as those found in IoT, 5G and remote sensing applications. Students learn how high-frequency front-ends work, to state and evaluate the specifications of the main building blocks and to face the trade-offs involved in their design.

6716 000 000 81683 - 0 - INTERNET OF THINGS	INF/01	INFO-01/A	6	48/0/0/0	No	Voto

Ambito: 1144 - Attivita' formative affini o integrative C

Obiettivi: Al termine dell'attività formativa, lo studente comprende le architetture e le metodologie alla base dell'Internet delle Cose (IoT) seguendo un approccio che pone al centro i dati. Lo studente ha una comprensione profonda dei protocolli di rete, dell'integrazione di dispositivi mobili e pervasivi, di piattaforme middleware per sistemi IoT M2M, di principi di computazione edge/distribuita/gateway, di nuovi servizi, di piattaforme di servizio e di scenari applicativi innovativi.

Obiettivi inglese: At the end of the course, the student understands the architectures and methodologies at the basis of the Internet of Things (IoT) following a data centric approach. The student has a deep understanding of network protocols, integration of mobile and pervasive end-devices, middleware platforms for M2M-based IoT systems, edge/distributed/gateway computing principles, new services, service platforms and innovative application scenarios.

6716 000 000 81610 - 0 - MACHINE LEARNING	ING-INF/05	IINF-05/A	6	48/0/0/0	No	Voto

Ambito: 1008 - A scelta dello studente D

Obiettivi: At the end of the course, the student has an understanding of theoretical foundations, computational properties, and use cases for some of the most popular supervised and unsupervised machine learning techniques. In particular, the student is able to address tasks such as classification, clustering, and discovery of rules by using modern machine learning methods and libraries.

Obiettivi inglese: At the end of the course, the student has an understanding of theoretical foundations, computational properties, and use cases for some of the most popular supervised and unsupervised machine learning techniques. In particular, the student is able to address tasks such as classification, clustering, and discovery of rules by using modern machine learning methods and libraries.

6716 000 000 93038 - 0 - OPTICAL TECHNOLOGIES FOR ELECTRICAL ENGINEERING M	ING-INF/02	IINF-02/A	6	120/0/0/0	No	Voto

Ambito: D

Obiettivi: Al termine del corso lo studente/la studentessa possiede familiarità con le caratteristiche di base delle Tecnologie Ottiche maggiormente utilizzate nell'area dell'Ingegneria Elettrica. Attraverso uno studio di componenti e dispositivi che si avvale di un approccio di tipo fisico e viene integrato da alcune esperienze di laboratorio, egli/ella è in grado di comprendere a fondo come le peculiarità di tali Tecnologie vengono sfruttate all'interno di Sistemi Elettrici e Smart Grid, per applicazioni di Telecomunicazioni, Monitoraggio e Sensoristica.

Obiettivi inglese: At the end of the course the student knows the basic characteristics of the Optical Technologies which are mainly utilized in the area of Electrical Engineering. Starting from a physically-based point of view, and taking advantage of some laboratory experiences, he/she deeply understands how the peculiar features of these Technologies are exploited within Electrical Systems and Smart Grids, for Communications, Monitoring and Sensing applications.

6716 000 000 95601 - 0 - OPTIMIZATION AND MACHINE LEARNING M	MAT/09	MATH-06/A	6	60/0/0/0	No	Voto

Ambito: 1144 - Attivita' formative affini o integrative C

Obiettivi: The aim of this course is to provide the student the ability of using both machine learning and mathematical optimization for advanced analytics. In particular, machine learning techniques are at the core of predictive analytics, where – based on historical data – one needs to predict the future outcome of a time series or classify unseen observations. Machine learning techniques build upon optimization techniques, and, in the case of neural networks, continuous optimization methods. Conversely, discrete optimization methods are at the core of prescriptive analytics, where one is required to make decisions optimizing a certain revenue / saving function by selecting within a discrete set. Discrete optimization methods are empowered by machine learning in estimating the parameters of the associated decision problems and, in some cases, benefit from machine learning to speed up the solution techniques.

Obiettivi inglese: The aim of this course is to provide the student the ability of using both machine learning and mathematical optimization for advanced analytics. In particular, machine learning techniques are at the core of predictive analytics, where – based on historical data – one needs to predict the future outcome of a time series or classify unseen observations. Machine learning techniques build upon optimization techniques, and, in the case of neural networks, continuous optimization methods. Conversely, discrete optimization methods are at the core of prescriptive analytics, where one is required to make decisions optimizing a certain revenue / saving function by selecting within a discrete set. Discrete optimization methods are empowered by machine learning in estimating the parameters of the associated decision problems and, in some cases, benefit from machine learning to speed up the solution techniques.

6716 000 000 69441 - 0 - OPTIMIZATION MODELS AND ALGORITHMS M	MAT/09	MATH-06/A	6	60/0/0/0	No	Voto

Ambito: 1144 - Attivita' formative affini o integrative C

Obiettivi: The goal of the course is to deal with Integer Programming that is a very powerful tool for modeling combinatorial optimization problems arising in many branches of engineering, industry and resource allocation. The first part of the course covers the modeling aspects of the field, providing the tools for constructing effective mathematical models, i.e., models that can be solved in practice. The second part is devoted to the algorithmic aspects: basic algorithms are reviewed and more sophisticated ones, useful for those models characterized by a large number of variables and/or constraints, are presented in detail. Finally, the third part of the course discusses real-world applications. At the end of the course students are able to formalize a combinatorial problem taken for the real life and run specific tools and algorithms for solving it in practice.

Obiettivi inglese: The goal of the course is to deal with Integer Programming that is a very powerful tool for modeling combinatorial optimization problems arising in many branches of engineering, industry and resource allocation. The first part of the course covers the modeling aspects of the field, providing the tools for constructing effective mathematical models, i.e., models that can be solved in practice. The second part is devoted to the algorithmic aspects: basic algorithms are reviewed and more sophisticated ones, useful for those models characterized by a large number of variables and/or constraints, are presented in detail. Finally, the third part of the course discusses real-world applications. At the end of the course students are able to formalize a combinatorial problem taken for the real life and run specific tools and algorithms for

solving it in practice.

6716 000 000 B5665 - 0 - REAL TIME SYSTEMS AND PROGRAMMING FOR AUTOMATION M	ING-INF/05	IINF-05/A	12	120/0/0/0	No	Voto

Ambito: D

Obiettivi: Alla fine del corso lo studente:
- conosce le basi di Python e programmazione a oggetti;
- ha familiarità con i concetti fondamentali relativi all'organizzazione e al funzionamento dei moderni sistemi operativi con un'enfasi sui sistemi realtime per l'automazione;
- sa realizzare semplici applicazioni concorrenti che usino chiamate a sistema e meccanismi di sincronizzazione;
- sa analizzare progettare e implementare semplici applicazioni concorrenti realtime.

Obiettivi inglese: At the end of the course, the student:
- knows the basics of Python and object oriented programming;
- is familiar with the fundamental concepts underlying modern operating system organization and functioning, with an emphasis on real-time systems for automation;
- is able to realize simple concurrent applications using system calls and synchronization mechanisms;
- is able to analyze, design and implement simple real-time concurrent applications.

6716 000 000 B8311 - 0 - SECURITY OF DATA AND NEURAL PROCESSING M	ING-INF/01	IINF-01/A	6	60/0/0/0	No	Voto

Ambito: B

Obiettivi: The course provides a basic knowledge of the fundamental concepts, terminology and problems in cryptography as well as tools for assessing the security of data protection schemes commonly employed.
It also provides high level requirements and design guidelines for typical blocks used in security-ensuring mechanisms.

Obiettivi inglese: The course provides a basic knowledge of the fundamental concepts, terminology and problems in cryptography as well as tools for assessing the security of data protection schemes commonly employed.
It also provides high level requirements and design guidelines for typical blocks used in security-ensuring mechanisms.

6716 000 000 87205 - 0 - TECHNOLOGIES AND APPLICATIONS OF WIRELESS POWER TRANSFER M	ING-INF/02	IINF-02/A	6	60/0/0/0	No	Voto

Ambito: 1008 - A scelta dello studente D

Obiettivi: The course aims at providing the rules for the analysis and design of a wireless link for the transmission of RF electromagnetic energy, exploiting both radiative techniques, by means of active antennas at the transmitter side and rectenna (rectifying antennas) at the receiver side, and non-radiative ones by inductive and capacitive coupling.The main non-linearities responsible for energy conversion, from RF to dc and vice versa, is studied and CAD tools based on the harmonic balancing technique are studied.The design process is also experimented by means of real-life systems based on simple energy reception systems for both radiation and reactive coupling mechanisms.

Obiettivi inglese: The course aims at providing the rules for the analysis and design of a wireless link for the transmission of RF electromagnetic energy, exploiting both radiative techniques, by means of active antennas at the transmitter side and rectenna (rectifying antennas) at the receiver side, and non-radiative ones by inductive and capacitive coupling.The main non-linearities responsible for energy conversion, from RF to dc and vice versa, is studied and CAD tools based on the harmonic balancing technique are studied.The design process is also experimented by means of real-life systems based on simple energy reception systems for both radiation and reactive coupling mechanisms.

6716 000 000 B5225 - 0 - TECHNOLOGY AND CHANGE IN GLOBAL POLITICS M	SPS/04	GSPS-02/A	6	30/0/0/0	No	Voto

Ambito: 1008 - A scelta dello studente D

Obiettivi: The course aims to provide students with advanced knowledge of the interplay between technology and international politics. The course looks at how technology has shaped change in the international system and how different states have used technology to advance their global positioning.
At the end of the course students is able to: a) discuss major transformations of the international system, b) understand how political factors can affect technological change.

Obiettivi inglese: The course aims to provide students with advanced knowledge of the interplay between technology and international politics. The course looks at how technology has shaped change in the international system and how different states have used technology to advance their global positioning.
At the end of the course students is able to: a) discuss major transformations of the international system, b) understand how political factors can affect technological change.

6716 000 000 73548 - 0 - WIRELESS SENSOR NETWORKS M	ING-INF/03	IINF-03/A	6	60/0/0/0	No	Voto	

Ambito: C

Obiettivi: This course introduces wireless communications for the Internet of Things (IoT). The course will describe the most used wireless technologies enabling the deployment of IoT networks. The theoretical part of the course will provide to students skills for designing an IoT network, accounting for connectivity, medium access control layer and routing issues, while considering the propagation environment where the network is located. Laboratory activities will allow students to use wireless devices to setup and run small IoT networks in a realistic environment and study their performance.

Obiettivi inglese: This course introduces wireless communications for the Internet of Things (IoT). The course will describe the most used wireless technologies enabling the deployment of IoT networks. The theoretical part of the course will provide to students skills for designing an IoT network, accounting for connectivity, medium access control layer and routing issues, while considering the propagation environment where the network is located. Laboratory activities will allow students to use wireless devices to setup and run small IoT networks in a realistic environment and study their performance.

Anno Accademico **2026/2027**
Classe **LM-29-INGEGNERIA ELETTRONICA**
Corso **6716-INGEGNERIA ELETTRONICA**

Curriculum: CURRICULUM INGEGNERIA ELETTRONICA (A75)

Primo Anno di Corso

Gruppo: 1) Attività formative obbligatorie

TAF: **Ambito:**

Cfu min: **Cfu max:**
Note:

Attività formativa	TIP	SSD	SSD 2024	TAF	CFU	ORE F/E/L/N	FREQ.	VER.
6716 000 000 34876 - 0 - ELETTRONICA DEI SISTEMI DIGITALI M		ING-INF/01	IINF-01/A	B	12	120/0/0/0	No	Voto

Ambito: 211 - Ingegneria elettronica

Obiettivi: Il corso si pone l'obiettivo di illustrare le metodologie di progetto dei circuiti integrati digitali a larga scala in tecnologia CMOS, con riferimento sia alle architetture circuitali che realizzano le più importanti funzioni logiche e aritmetiche sia alle tecniche di progettazione assistita ai vari livelli di astrazione. A tal fine, una parte importante del corso è dedicata a esercitazioni guidate volte a permettere allo studente di affrontare e risolvere alcuni problemi di progetto e caratterizzazione di moduli digitali di complessità crescente utilizzando programmi di progettazione assistita.

6716 000 000 35367 - 0 - ELETTRONICA INDUSTRIALE M		ING-INF/01	IINF-01/A	B	6	60/0/0/0	No	Voto

Ambito: 211 - Ingegneria elettronica

Obiettivi: Illustrare i princìpi di funzionamento dei sistemi elettronici che trovano applicazione nelle macchine e negli impianti industriali.

6716 000 000 B2250 - 0 - MICROELETTRONICA M		ING-INF/01	IINF-01/A	B	9	90/0/0/0	No	Voto

Ambito: 211 - Ingegneria elettronica

Obiettivi: Illustrazione dei metodi di fabbricazione dei circuiti integrati. Analisi del funzionamento dei principali dispositivi a semiconduttore. Introduzione ai dispositivi di ultima generazione. Analisi di alcuni sensori integrati. Progettazione assistita dal calcolatore.

Obiettivi inglese: Fabrication methods for the integrated circuits. Functioning of the most important semiconductor devices. Introduction to the ultimate-generation devices. Analysis of integrated sensors. Computer-aided design.

6716 000 000 81649 - 0 - PROGETTO DI CIRCUITI E SISTEMI ANALOGICI M	ING-INF/01	IINF-01/A	B	9	90/0/0/0	No	Voto

Ambito: 211 - Ingegneria elettronica
Obiettivi: Illustrare il funzionamento e i criteri di progetto dei blocchi analogici fondamentali.

6716 000 000 B8309 - 0 - STATISTICA E MACHINE LEARNING PER L'ELABORAZIONE DEI SEGNALI M	ING-INF/01	IINF-01/A	B	9	90/0/0/0	No	Voto

Ambito: 211 - Ingegneria elettronica
Obiettivi: Il corso fornisce gli strumenti matematici di base per l'elaborazione dei segnali con particolare enfasi sul modello statistico dell'informazione, il punto di vista geometrico, il ruolo dell'ottimizzazione e un cenno all'apprendimento automatico per reti neurali. Applica tali concetti alla definizione e alla soluzione dei tipici problemi fondamentali: dalla sintesi di filtri lineari alla predizione, dalla stima di spettro alla modellazione del rumore.

Gruppo: 2) Attività formative a scelta

TAF: C Ambito: 1144 - Attivita' formative affini o integrative

Cfu min: 12 Cfu max: 12
Note: Scegli 12 crediti tra le seguenti attività formative:

Attività formativa	TIP	SSD	SSD 2024	TAF	CFU	ORE F/E/L/N	FREQ.	VER.
6716 000 000 69430 - 0 - ARCHITETTURA DEI CALCOLATORI ELETTRONICI M		ING-INF/05	IINF-05/A	C	6	60/0/0/0	No	Voto

Ambito: 1144 - Attivita' formative affini o integrative
Obiettivi: Illustrare sistemi a microprocessori a parallelismo multibyte, sistemi di memorie multibyte, agenti hardware intelligenti, schede reali basate su microprocessore x86, architetture avanzate, tecnologie cache, sistemi impaginati e segmentati, famiglia Pentium, pipelinining, accesso burst e temporizzazioni, cache di secondo livello e sistemi multiprocessore, esecuzione out-of-order e tecnologie implementative, i processori Pentium II, III e IV e i chip di supporto, interfacciamento delle memorie dinamiche.

6716 000 000 87269 - 0 - AUTOMATION SOFTWARE AND DESIGN PATTERNS M	ING-INF/04	IINF-04/A	C	6	60/0/0/0	No	Voto

Ambito: 1144 - Attivita' formative affini o integrative
Obiettivi: Il corso si propone di fornire una visione razionale delle principali problematiche, metodi, schemi di progettazione e ambienti di sviluppo per l'implementazione dei moderni sistemi di automazione. Il corso si concentrerà sulla generazione model-based di macchine a stati finiti, livelli di astrazione basati su Input e Output Bridges, Generic Devices e Generic Axes e sistemi di gestione dei guasti. Al termine del corso gli studenti sono in grado di padroneggiare aspetti progettuali di architetture software avanzate per macchine automatiche complesse, definendo modelli e soluzioni flessibili per i problemi più comuni, indipendentemente dall'architettura della macchina e dell'hardware di controllo.

Obiettivi inglese: The course aims to provide a rational view of the main principles, methodological issues, design patterns and integrated development environments involved in the implementation of modern automation systems. The course will focus on model driven generation of Finite State Machines, connection layers based on Input and Output Bridges, Generic Devices and Generic Axes and fault managment systems. At the end of the course students are able to master design aspects of advanced software architectures for complex automated machines, defining models and flexible solutions for common problems independently from the machine and hardware architecture.

6716 000 000 35425 - 0 - BIOIMMAGINI E INGEGNERIA CLINICA M	ING-INF/06	IBIO-01/A	C	6	60/0/0/0	No	Voto

Ambito: 1144 - Attivita' formative affini o integrative
Obiettivi: Gestione e normativa delle apparecchiature biomediche. Sistemi informativi sanitari ed elementi di telemedicina. Il dimensionamento dei servizi sanitari. La diagnostica per immagini. Elaborazione di immagini biomediche: metodi di filtraggio e segmentazione. Visualizzazione assistita al calcolatore. Tecniche di realtà virtuale in biomedicina.

6716 000 000 35374 - 0 - BIOINGEGNERIA DELLA RIABILITAZIONE M	ING-IND/34	IBIO-01/A	6	60/0/0/0	No	Voto

Ambito: 1144 - Attivita' formative affini o integrative C

Obiettivi: Fornire allo Studente un quadro sulle problematiche della disabilità, gli ausili utilizzati e le tecniche per la valutazione funzionale con particolare riferimento alla neuroriabilitazione e neuroprotesi nel controllo della postura e del movimento, alla protesi e ortesi per arti superiori e inferiori, e al monitoraggio remoto, applicazioni domotiche e realtà virtuale.

6716 000 000 29145 - 0 - COMPLEMENTI DI ANALISI MATEMATICA M	MAT/05	MATH-03/A	6	60/0/0/0	No	Voto

Ambito: 1144 - Attivita' formative affini o integrative C

Obiettivi: Lo studente consolida la preparazione matematica con particolare riguardo alle equazioni differenziali ordinarie lineari e non lineari e alle equazioni a derivate parziali lineari del primo e del secondo ordine, applicando le più significative condizioni ai limiti per i vari tipi di equazioni. Approfondisce alcuni strumenti necessari per tale studio e che presentano anche un autonomo interesse, quali le serie di Fourier e le trasformate di Fourier e di Laplace.

6716 000 000 99195 - 0 - CYBER-PHYSICAL SYSTEMS PROGRAMMING M	ING-INF/05	IINF-05/A	6	60/0/0/0	No	Voto

Ambito: 1144 - Attivita' formative affini o integrative C

Obiettivi: Il corso fornisce allo studente una conoscenza di base delle architetture software e gli ambienti di sviluppo, programmazione e progettazione di sistemi cyber-fisici, con particolare enfasi alla coesistenza di task di controllo, processing di data stream, e comunicazione IoT con requisiti di real-time e cybersecurity. Nel corso lo studente impara a utilizzare compilatori, librerie, runtime e middleware per piattaforme e architetture eterogenee, dotate di processori multicore, co-processori e acceleratori HW e SW per il processing di stream di dati da sensori e verso attuatori.

Obiettivi inglese: The course provides the student with a basic knowledge of software architectures as well as the development, programming and design environments for cyber-physical systems, with particular emphasis on the coexistence of control tasks, data stream processing, and IoT communication with real-time and cybersecurity requirements. The student will learn to use compilers, libraries, runtimes and middleware for heterogeneous platforms and architectures, equipped with multicore processors, co-processors and HW and SW accelerators for the processing of data streams from sensors and towards actuators.

6716 000 000 35371 - 0 - ELABORAZIONE DI DATI E SEGNALI BIOMEDICI M	ING-INF/06	IBIO-01/A	6	60/0/0/0	No	Voto

Ambito: 1144 - Attivita' formative affini o integrative C

Obiettivi: Fornire allo Studente gli strumenti conoscitivi e metodologici per estrarre l'informazione utile da un segnale biomedico, interpretare i risultati e convalidare i descrittori ottenuti alla luce di elementi di conoscenza del sistema biologico coinvolto, produrre innovazione nell'ambito del miglioramento delle conoscenze fisiologiche, della produzione di nuove apparecchiature mediche "intelligenti", e della definizione di nuovi protocolli clinici di prevenzione, diagnosi e cura.

6716 000 000 37125 - 0 - ELECTROMAGNETIC COMPATIBILITY M	ING-IND/31	IIET-01/A	6	60/0/0/0	No	Voto

Ambito: 1144 - Attivita' formative affini o integrative C

Obiettivi: Il corso si propone di fornire la conoscenza delle principali problematiche relative alla compatibilità elettromagnetica delle apparecchiature elettriche e/o elettroniche. Vengono trattate la diafonia, le emissioni condotte e irradiate e l’immunità condotta e radiata, e ne sono ricavati modelli per l’analisi. Sono fornite le competenze per la soluzione di problemi di interferenza condotta e irradiata, con particolare riferimento ai filtri EMI, ai metodi e alle tecniche di schermatura elettromagnetica e alle misure in camera riverberante. Sono fornite inoltre le conoscenze dei fenomeni alla base della propagazione delle onde elettromagnetiche sia in mezzi illimitati sia guidata. Gli argomenti sono proposti agli studenti con particolare riferimento agli aspetti applicativi, accompagnando la teoria con attività di esercitazione numerica e di laboratorio.

Obiettivi inglese: The course provides the knowledge of the main concepts in the field of electromagnetic compatibility of electric/electronic devices. The main topics are crosstalk, conducted and radiated emissions with models for the analysis. The students are given an understanding for the solution of conducted and radiated electromagnetic interference, with particular reference to EMI filters, methods and techniques of electromagnetic shielding and measurement in reverberation chamber. The basic knowledge of electromagnetic wave propagation both in an arbitrary medium and in guiding structures is also provided. The topics are presented with reference to practical applications. Lectures are integrated with numerical and laboratory demos.

6716 000 000 69661 - 0 - IMAGE PROCESSING AND COMPUTER VISION M	ING-INF/05	IINF-05/A	6	60/0/0/0	No	Voto

Ambito: 1144 - Attivita' formative affini o integrative C

Obiettivi: Introducing basic knowledge about algorithms, tools and systems for the management, processing and analysis of digital images. The main topics of the course are filtering aspects of digital images, algorithms for image processing, algorithms for segmentation and classification of objects in digital images. Theoretical aspects that are introduced in the course are then applied to the design and manufacturing capabilities of simple systems oriented to real world applications. At the end of the course students are able to master basic digital image processing techniques and know potentials of this technology in applicative research and industrial contexts.

Obiettivi inglese: Introducing basic knowledge about algorithms, tools and systems for the management, processing and analysis of digital images. The main topics of the course are filtering aspects of digital images, algorithms for image processing, algorithms for segmentation and classification of objects in digital images. Theoretical aspects that are introduced in the course are then applied to the design and manufacturing capabilities of simple systems oriented to real world applications. At the end of the course students are able to master basic digital image processing techniques and know potentials of this technology in applicative research and industrial contexts.

6716 000 000 73548 - 0 - WIRELESS SENSOR NETWORKS M	ING-INF/03	IINF-03/A		6	60/0/0/0	No	Voto

Ambito: C

Obiettivi: This course introduces wireless communications for the Internet of Things (IoT). The course will describe the most used wireless technologies enabling the deployment of IoT networks. The theoretical part of the course will provide to students skills for designing an IoT network, accounting for connectivity, medium access control layer and routing issues, while considering the propagation environment where the network is located. Laboratory activities will allow students to use wireless devices to setup and run small IoT networks in a realistic environment and study their performance.

Obiettivi inglese: This course introduces wireless communications for the Internet of Things (IoT). The course will describe the most used wireless technologies enabling the deployment of IoT networks. The theoretical part of the course will provide to students skills for designing an IoT network, accounting for connectivity, medium access control layer and routing issues, while considering the propagation environment where the network is located. Laboratory activities will allow students to use wireless devices to setup and run small IoT networks in a realistic environment and study their performance.

Secondo Anno di Corso

Gruppo: 1) Prova finale

TAF: Ambito:

Cfu min: 18 Cfu max: 18

Note: Lo studente può scegliere di svolgere la sola prova finale (Gruppo A) oppure la prova finale e un'attività a scelta tra il tirocinio in preparazione della prova finale, il tirocinio in preparazione della prova finale all'estero o la preparazione della prova finale all'estero (Gruppo B).

Attività formativa	TIP	SSD	SSD 2024	TAF	CFU	ORE F/E/L/N	FREQ.	VER.
1.1) Gruppo A					0-18			
6716 000 000 34634 - 0 - PROVA FINALE					18	0/0/0/0	No	

Ambito: 1018 - Per la prova finale E

Obiettivi: Preparazione e svolgimento della prova finale secondo le indicazioni del presente Regolamento.

1.2) Gruppo B					0-18			
6716 000 000 82271 - 0 - PREPARAZIONE PROVA FINALE ALL'ESTERO					15	0/0/375/0	No	Giudizio

Ambito: 1018 - Per la prova finale E

Obiettivi: Al termine della preparazione alla prova finale all’estero lo studente è in grado di interagire con professionalità diverse, sa lavorare in gruppo, sviluppa le proprie abilità comunicative in lingua straniera, sa redigere relazioni tecniche relative ai progetti effettuati e sa interpretare relazioni tecniche scritte dai collaboratori all'interno dell'argomento scelto per la prova finale.

6716 000 000 82301 - 0 - PROVA FINALE					3	0/0/0/0	No	

Ambito: 1018 - Per la prova finale E

Obiettivi: Consentire allo studente, mediante la redazione della tesi di laurea, di dimostrare di saper utilizzare in autonomia le competenze acquisite per affrontare e risolvere problemi significativi di una o più discipline del Corso di Laurea Magistrale.

6716 000 000 82272 - 0 - TIROCINIO IN PREPARAZIONE DELLA PROVA FINALE					15	0/0/375/0	No	Giudizio

Ambito: 1018 - Per la prova finale E

Obiettivi: Favorire il contatto degli studenti con le problematiche aziendali attraverso la preparazione della tesi di laurea magistrale, sulla base di un progetto concordato con il relatore.

6716 000 000 B5529 - 0 - TIROCINIO IN PREPARAZIONE DELLA PROVA FINALE ALL'ESTERO		15	0/0/375/0	No	Giudizio

Ambito: 1018 - Per la prova finale E

Obiettivi: Favorire il contatto degli studenti con le problematiche aziendali attraverso la preparazione della tesi di laurea magistrale all'estero, sulla base di un progetto concordato con il relatore.

Gruppo: 2) Attività formative a scelta

TAF: B Ambito: 211 - Ingegneria elettronica

Cfu min: 24 Cfu max: 24

Note: Scegli 24 crediti tra le seguenti attività formative:

Attività formativa	TIP	SSD	SSD 2024	TAF	CFU	ORE F/E/L/N	FREQ.	VER.
6716 000 000 35364 - 0 - ARCHITETTURE DIGITALI PER L'ELABORAZIONE DEL SEGNALE M		ING-INF/01	IINF-01/A	B	6	60/0/0/0	No	Voto

Ambito: 211 - Ingegneria elettronica

Obiettivi: Illustrare le architetture digitali piú in uso per la elaborazione del segnale. Partendo dallo studio di alcuni significativi algoritmi di elaborazione del segnale audio e video, si desumono le specifiche che debbono essere soddisfatte da architetture hardware par la elaborazione del segnale. L'analisi delle architetture piú in uso, seriali e parallele, viene svolta osservando la stretta correlazione tra specifiche algoritmiche ed architetturali nell'ambito di questa classe di macchine.

6716 000 000 99191 - 0 - DISPOSITIVI, CIRCUITI ED ALGORITMI PER IL CALCOLO QUANTISTICO M	ING-INF/01	IINF-01/A	B	6	60/0/0/0	No	Voto

Ambito: 211 - Ingegneria elettronica

Obiettivi: Il corso introduce i concetti fondamentali per comprendere i sistemi hardware e software alla base del calcolo quantistico. Al termine, lo studente padroneggia i principi alla base del calcolo quantistico, la comprensione del modello di circuito quantistico, i principali algoritmi proposti, i concetti fisici alla base dell'implementazione dei sistemi hardware e le principali architetture elettroniche.

Obiettivi inglese: The course introduces the fundamental concepts for understanding the hardware and software systems underlying quantum computing. Upon completion, the student masters the principles underlying quantum computation, an understanding of the quantum circuit model, the main algorithms, the physical concepts underlying the implementation of hardware systems, and the main electronic architectures.

6716 000 000 90392 - 0 - ELEMENTS OF APPLIED DATA SECURITY M	ING-INF/01	IINF-01/A	B	6	60/0/0/0	No	Voto

Ambito:

Obiettivi: The course provides a basic knowledge of the fundamental concepts, terminology and problems in cryptography as well as tools for assessing the security of data protection schemes commonly employed. It also provides high level requirements and design guidelines for typical blocks used in security-ensuring mechanisms.

Obiettivi inglese: The course provides a basic knowledge of the fundamental concepts, terminology and problems in cryptography as well as tools for assessing the security of data protection schemes commonly employed.
It also provides high level requirements and design guidelines for typical blocks used in security-ensuring mechanisms.

6716 000 000 93322 - 0 - HARDWARE-SOFTWARE DESIGN OF IOT SYSTEMS M	ING-INF/01	IINF-01/A	B	6	60/0/0/0	No	Voto

Ambito: 211 - Ingegneria elettronica

Obiettivi: L'obiettivo principale del corso è fornire metodologie per l'analisi e la programmazione di sistemi elettronici embedded single-core e multi-core. Viene sottolineata l'importanza dei componenti software in tutti i sistemi elettronici. Le principali conoscenze e competenze da conseguire sono (i) una chiara comprensione delle architetture hardware embedded programmabili più comuni e delle piattaforme hardware-software; (ii) metodologie per l'analisi comparativa e approcci per stimare gli indicatori chiave di prestazione (KPI) come costi, prestazioni, efficienza energetica, per valutare quantitativamente l'utilizzo di una piattaforma hardware-software per un dominio applicativo (ad esempio automobilistico, di consumo, industriale) e per un'applicazione specifica; (iii) tecniche di sviluppo e verifica del software embedded, tenendo conto dei vincoli tipici e degli indicatori chiave di prestazione che differenziano i sistemi embedded dai sistemi informatici generici; (iv) metodi e strumenti di ottimizzazione del software per hardware embedded sia single-core che multi-core.

Obiettivi inglese: The main goal of the class is to provide methodologies for analyzing and programming singe-core and multi-core embedded electronic systems. The importance of software components in virtually all electronic systems is emphasized. The key learning outcomes are (i) a clear understanding of the most common programmable embedded hardware architectures and hardware-software platforms; (ii) methodologies for comparative analysis and approaches to estimate key performance indicators (KPIs) such as cost, performance, energy efficiency, to quantitatively assess the matching of a hardware-software platform for an application domain (e.g. automotive, consumer, industrial) and for a specific application; (iii) embedded software development and verification techniques, taking into account typical constraints and

performance KPIs that differentiate embedded systems from general-purpose computing systems; (iv) hardware-aware software optimization methods and tools for both single-core and multi-core embedded hardware.

6716 000 000 84442 - 0 - HIGH FREQUENCY ELECTRONIC CIRCUITS M | ING-INF/01 | IINF-01/A | 6 | 60/0/0/0 | No | Voto

Ambito: 211 - Ingegneria elettronica B

Obiettivi: The course deals with the analysis and design of high-frequency electronic circuits as those found in IoT, 5G and remote sensing applications. Students learn how high-frequency front-ends work, to state and evaluate the specifications of the main building blocks and to face the trade-offs involved in their design.

Obiettivi inglese: The course deals with the analysis and design of high-frequency electronic circuits as those found in IoT, 5G and remote sensing applications. Students learn how high-frequency front-ends work, to state and evaluate the specifications of the main building blocks and to face the trade-offs involved in their design.

6716 000 000 69437 - 0 - NANOELETTRONICA M | ING-INF/01 | IINF-01/A | 6 | 60/0/0/0 | No | Voto

Ambito: 211 - Ingegneria elettronica B

Obiettivi: Il corso si propone di fornire agli studenti che lo frequentano gli strumenti concettuali per affrontare lo studio dei dispositivi a dimensione nanometrica. La complessità delle equazioni quantiche del trasporto rende difficile lo sviluppo di modelli compatti e obbliga all'adozione di tecniche numeriche per la loro soluzione. Pertanto, il corso comprenderà nel proprio programma anche lo studio dei principali metodi numerici per la soluzione dell'equazione di Schrödinger a contorno sia chiuso che aperto, per il quale ha oggi assunto una grande popolarità il formalismo della funzione di Green di non equilibrio (NEGF). I dispositivi oggetto di studio comprenderanno, per la loro importanza preminente, i transitori ultrasottili di silicio su isolante (SOI), i fili quantici di silicio (NW-FET) e i dispositivi multi-gate (MG-FET), recentemente annunciati da Intel come componenti base del nodo tecnologico a 22 nanometri. Il corso esaminerà altresì dispositivi a eterostruttura basati su semiconduttori composti III-V, il cui interesse per le applicazioni digitali sta oggi aumentando a livello di ricerca per la realizzazione di componenti dotati di una transizione veloce fra lo stato di spegnimento e quello di accensione. Sono fra questi i transistori a effetto tunnel banda a banda e i super-reticoli (SL-FET) che, per la loro proprietà di filtraggio degli elettroni ad alta energia, rendono possibili pendenze inverse sotto soglia molto minori di (kBT/q) ln(10) = 60 mV/dec.

6716 000 000 81654 - 0 - PROGETTO DI CIRCUITI ANALOGICI AVANZATI M | ING-INF/01 | IINF-01/A | 6 | 60/0/0/0 | No | Voto

Ambito: 1008 - A scelta dello studente B

Obiettivi: Illustrare il funzionamento e i criteri di progetto dei blocchi analogici fondamentali.

6716 000 000 99192 - 0 - SISTEMI ELETTRONICI AD ALTA AFFIDABILITA' E RESILIENZA M | ING-INF/01 | IINF-01/A | 6 | 60/0/0/0 | No | Voto

Ambito: 211 - Ingegneria elettronica B

Obiettivi: Studiare le tecniche di collaudo e progettazione orientata al collaudo di circuiti e sistemi integrati, e le strategie di progettazione di circuiti e sistemi integrati ad alta affidabilità e resilienza.

Obiettivi inglese: To study the techniques for testing and design for testability of integrated circuits and systems, and the design strategies for integrated circuits and systems with high reliability and resiliency.

6716 000 000 35424 - 0 - SISTEMI INTEGRATI PER L'ANALISI SPETTRALE M | ING-INF/01 | IINF-01/A | 6 | 60/0/0/0 | No | Voto

Ambito: 211 - Ingegneria elettronica B

Obiettivi: Fornire le metodologie e le tecniche di progettazione di sistemi integrati per l'acquisizione, l'elaborazione e la classificazione di dati, segnali ed immagini mediante l'impiego di algoritmi e sistemi avanzati.

6716 000 000 87198 - 0 - STATISTICS AND ARCHITECTURES FOR BIG DATA PROCESSING M | ING-INF/01 | IINF-01/A | 6 | 60/0/0/0 | No | Voto

Ambito: 211 - Ingegneria elettronica B

Obiettivi: The course provides students with a basic knowledge of problems and corresponding techniques of solutions implied by the ever increasing amount and complexity of the data available for analyses and decisions, i.e., the so called Big-Data (BD). The corresponding issues are tackled by multiple points of view: from the abstract characterization of the mathematical properties of BD, to the hardware architectures needed to process them.

Obiettivi inglese: The course provides students with a basic knowledge of problems and corresponding techniques of solutions implied by the ever increasing amount and complexity of the data available for analyses and decisions, i.e., the so called Big-Data (BD). The corresponding issues are tackled by multiple points of view: from the abstract characterization of the mathematical properties of BD, to the hardware architectures needed to process them.

Gruppo: 3) Altre attività formative

TAF: F Ambito: 0000 - Nessun Ambito

Cfu min: 9 Cfu max: 9
Note: Scegli 9 crediti tra le seguenti attività formative:

Attività formativa	TIP	SSD	SSD 2024	TAF	CFU	ORE F/E/L/N	FREQ.	VER.
6716 000 000 93393 - 0 - ELECTRONIC FRONTIERS M					3	30/0/0/0	No	Giudizio

Ambito: F

Obiettivi: The course will address challenges in emerging technologies and architectures for intelligent systems, big data and internet of things, possibly changing year to year.

Obiettivi inglese: The course will address challenges in emerging technologies and architectures for intelligent systems, big data and internet of things, possibly changing year to year.

6716 000 000 87195 - 0 - LAB OF BIG DATA ARCHITECTURES M					3	0/0/30/0	No	Giudizio

Ambito: 0000 - Nessun Ambito F

Obiettivi: The Lab of Big Data architectures extends and integrates what learnt by the student in the course statistics and architectures for big data processing with a more in depth and practical knowledge of the big-data technologies and architectures. The students will learn how to design a big data system, the key concepts and differentiators behind state-of-the-art technologies and architectures, and how to use it effectively. This will be done by a series of practical exercises with interactive explanations, where students will learn by solving practical problems and examples.

Obiettivi inglese: The Lab of Big Data architectures extends and integrates what learnt by the student in the course statistics and architectures for big data processing with a more in depth and practical knowledge of the big-data technologies and architectures. The students will learn how to design a big data system, the key concepts and differentiators behind state-of-the-art technologies and architectures, and how to use it effectively. This will be done by a series of practical exercises with interactive explanations, where students will learn by solving practical problems and examples.

6716 000 000 84419 - 0 - LAB OF DIGITAL ELECTRONICS M					3	30/0/0/0	No	Giudizio

Ambito: F

Obiettivi: Aim of this course is to enrich the practical experience of the students on advanced digital hardware design tools and methodologies. The students are expected to work on a practical project to deeper their knowledge in digital hardware design, integration of hardware modules into Systems on Chip, and prototyping of digital systems on FPGA devices. The course will also cover aspects related to interactions between software and hardware components in Systems on Chip.

Obiettivi inglese: Aim of this course is to enrich the practical experience of the students on advanced digital hardware design tools and methodologies. The students are expected to work on a practical project to deeper their knowledge in digital hardware design, integration of hardware modules into Systems on Chip, and prototyping of digital systems on FPGA devices. The course will also cover aspects related to interactions between software and hardware components in Systems on Chip.

6716 000 000 72972 - 0 - LAB OF HIGH-FREQUENCY CIRCUIT DESIGN M					3	0/0/30/0	No	Giudizio

Ambito: 0000 - Nessun Ambito F

Obiettivi: Learning the specific procedures for the analysis and the design of RF, microwave and modelling -wave circuits by using the most advanced CAD tools. Specific projects will be assigned to students. Each project will consist in the design of a typical RF or microwave circuit exploited in communication system front-ends (e.g. transmitters, receivers, transponders, transceivers) or in high-frequency remote sensor systems (e.g. radars, SARs, altimeters).

Obiettivi inglese: Learning the specific procedures for the analysis and the design of RF, microwave and modelling -wave circuits by using the most advanced CAD tools. Specific projects will be assigned to students. Each project will consist in the design of a typical RF or microwave circuit exploited in communication system front-ends (e.g. transmitters, receivers, transponders, transceivers) or in high-frequency remote sensor systems (e.g. radars, SARs, altimeters).

6716 000 000 93324 - 0 - LAB OF INTELLIGENT SENSOR SYSTEMS M | 3 | 0/0/30/0 | No | Giudizio

Ambito: F

Obiettivi: Compensation of amplifiers, opamp macromodels, high slew-rate opamp, instrumentation opamps, opamp characterization and non- idealities, noise in the opamps. Use of Spice as a circuit simulator.

Obiettivi inglese: Compensation of amplifiers, opamp macromodels, high slew-rate opamp, instrumentation opamps, opamp characterization and non- idealities, noise in the opamps. Use of Spice as a circuit simulator.

6716 000 000 93323 - 0 - LAB OF RELIABLE INTELLIGENT SYSTEMS M | 3 | 0/0/30/0 | No | Giudizio

Ambito: F

Obiettivi: Circuit level design and verification by electrical level and Monte Carlo simulations performed by the tool HSPICE. Circuit reliability analysis by electrical level simulations performed by the tool HSPICE. System integration and synthesis performed by the tool Synopsys Design Compiler. System reliability evaluation by fault injection and simulation performed by the tool Synopsys Tetramax. System implementation by Field Programmable Gate Arrays (FPGAs) performed by the Xilinx implementation tool.

Obiettivi inglese: Circuit level design and verification by electrical level and Monte Carlo simulations performed by the tool HSPICE. Circuit reliability analysis by electrical level simulations performed by the tool HSPICE. System integration and synthesis performed by the tool Synopsys Design Compiler. System reliability evaluation by fault injection and simulation performed by the tool Synopsys Tetramax. System implementation by Field Programmable Gate Arrays (FPGAs) performed by the Xilinx implementation tool.

6716 000 000 B5523 - 0 - LABORATORIO DI ARCHITETTURE DIGITALI PER L'ELABORAZIONE DEL SEGNALE M | 3 | 0/0/30/0 | No | Giudizio

Ambito: F

Ambito:

Obiettivi: Al termine dell'attività formativa lo studente è in grado di sviluppare in autonomia il progetto di un sistema digitale di elaborazione del segnale, partendo dalla formulazione a livello algoritmico ed arrivando ad una soluzione architetturale ottimizzata, integrata in un sistema digitale complesso (System-on-Chip), implementata mediante flusso digitale VLSI e/o FPGA. Lo studente acquisisce altresì le competenze necessarie per la valutazione del progetto realizzato in termini di performance, area e consumo di potenza.

Obiettivi inglese: At the end of the activity the student is able to develop autonomously the project of a digital signal processing system, starting from its algorithmic formulation and achieving an optimized architectural solution integrated into a complex digital system (System-on-Chip). The implementation is carried out through VLSI and/or FPGA digital flow. Additionally, the student gains the necessary skills for evaluating the quality of the project in terms of performance, area and power consumption.

6716 000 000 99194 - 0 - LABORATORIO DI STRUMENTAZIONE ELETTRONICA AUTOMATIZZATA M | 3 | 0/0/30/0 | No | Giudizio

Ambito: F

Ambito:

Obiettivi: Apprendere le modalità di progetto e utilizzo dei moderni sistemi automatici di misura ed acquisizione dati basati su strumentazione digitale e virtuale gestita da calcolatore, con particolare enfasi alle applicazioni in campo industriale e scientifico.

6716 000 000 B5525 - 0 - TIROCINIO IN ICT M | 6 | 0/0/150/0 | No | Giudizio

Ambito: F

Obiettivi: Tirocinio in ambito ICT soggetto ad approvazione ad parte della Commissione Tirocini

Obiettivi inglese: Internship in ICT to be approved by the Degree's Internship Committee

Gruppo: 4) Attività formative a scelta libera consigliate

TAF: D Ambito: 1008 - A scelta dello studente

Cfu min: 12 Cfu max: 12

Note: Scegli 12 crediti tra tutte le attività formative dell'Ateneo. Il Corso di Studio considera coerenti con il percorso formativo le seguenti:

Attività formativa	TIP	SSD	SSD 2024	TAF	CFU	ORE F/E/L/N	FREQ.	VER.

6716 000 000 82072 - 0 - ANTENNAS FOR WIRELESS SYSTEMS M	ING-INF/02	IINF-02/A	6	60/0/0/0	No	Voto

Ambito: 1008 - A scelta dello studente D

Obiettivi: The role of antenna as strategic interface between transmitter/receiver and channel. Design rules for the principal families of antennas (wire, aperture, and microstrip antennas), and for their combination in array architectures. Exploitation of antennas in modern energy-aware applications, such as radio-frequency energy harvesting or wireless power transfer systems.

Obiettivi inglese: The role of antenna as strategic interface between transmitter/receiver and channel. Design rules for the principal families of antennas (wire, aperture, and microstrip antennas), and for their combination in array architectures. Exploitation of antennas in modern energy-aware applications, such as radio-frequency energy harvesting or wireless power transfer systems.

6716 000 000 93398 - 0 - ARCHITECTURES FOR ARTIFICIAL INTELLIGENCE M	ING-INF/01	IINF-01/A	6	60/0/0/0	No	Voto

Ambito: 1008 - A scelta dello studente D

Obiettivi: The main goal of the class is to enable students to specify, configure, program and verify complex embedded electronic systems for the Internet of Things and for Artificial Intelligence. The importance of hardware-software interaction will be emphasized, as all practical IoT and AI systems are programmable. The class will provide working knowledge on state-of-the-art hardware platforms used in embedded AI and IoT applications - spanning a wide range of power and cost vs. performance tradeoffs. A detailed coverage will be given of software abstractions and methodologies for developing applications leveraging the capabilities of the above mentioned platforms. Design automation tools and flows will also be covered.

Obiettivi inglese: The main goal of the class is to enable students to specify, configure, program and verify complex embedded electronic systems for the Internet of Things and for Artificial Intelligence. The importance of hardware-software interaction will be emphasized, as all practical IoT and AI systems are programmable. The class will provide working knowledge on state-of-the-art hardware platforms used in embedded AI and IoT applications - spanning a wide range of power and cost vs. performance tradeoffs. A detailed coverage will be given of software abstractions and methodologies for developing applications leveraging the capabilities of the above mentioned platforms. Design automation tools and flows will also be covered.

6716 000 000 69430 - 0 - ARCHITETTURA DEI CALCOLATORI ELETTRONICI M	ING-INF/05	IINF-05/A	6	60/0/0/0	No	Voto

Ambito: 1144 - Attivita' formative affini o integrative C

Obiettivi: Illustrare sistemi a microprocessori a parallelismo multibyte, sistemi di memorie multibyte, agenti hardware intelligenti, schede reali basate su microprocessore x86, architetture avanzate, tecnologie cache, sistemi impaginati e segmentati, famiglia Pentium, pipelinining, accesso burst e temporizzazioni, cache di secondo livello e sistemi multiprocessore, esecuzione out-of-order e tecnologie implementative, i processori Pentium II, III e IV e i chip di supporto, interfacciamento delle memorie dinamiche.

6716 000 000 35364 - 0 - ARCHITETTURE DIGITALI PER L'ELABORAZIONE DEL SEGNALE M	ING-INF/01	IINF-01/A	6	60/0/0/0	No	Voto

Ambito: 211 - Ingegneria elettronica B

Obiettivi: Illustrare le architetture digitali piú in uso per la elaborazione del segnale. Partendo dallo studio di alcuni significativi algoritmi di elaborazione del segnale audio e video, si desumono le specifiche che debbono essere soddisfatte da architetture hardware par la elaborazione del segnale. L'analisi delle architetture piú in uso, seriali e parallele, viene svolta osservando la stretta correlazione tra specifiche algoritmiche ed architetturali nell'ambito di questa classe di macchine.

6716 000 000 B5224 - 0 - ARTIFICIAL INTELLIGENCE FOR MEDICINE M	ING-INF/06	IBIO-01/A	6	60/0/0/0	No	Voto

Ambito: 1144 - Attivita' formative affini o integrative C

Obiettivi: At the end of the course, the student has:
-knowledge regarding the need for AI in Medicine;
-understanding of weaknesses of AI techniques, methods to overcome the challenges of AI in Medicine, and ways in which AI may improve healthcare;
-essential knowledge to develop and implement reliable AI solutions in clinical research (using, e.g., supervised and unsupervised machine and deep learning techniques, explainable AI methods, and generative adversarial techniques);
-practical skills to develop state-of-the-art AI tools with real-world medical data (e.g., clinical and imaging data);
-the ability to critically read, discuss and evaluate methods and results of studies using AI in Medicine;
-an overview of state-of-the-art AI-powered tools in Medicine.

Obiettivi inglese: At the end of the course, the student has:
-knowledge regarding the need for AI in Medicine;
-understanding of weaknesses of AI techniques, methods to overcome the challenges of AI in Medicine, and ways in which AI may improve healthcare;
-essential knowledge to develop and implement reliable AI solutions in clinical research (using, e.g., supervised and unsupervised machine and deep learning techniques, explainable AI methods, and generative adversarial techniques);
-practical skills to develop state-of-the-art AI tools with real-world medical data (e.g., clinical and imaging data);
-the ability to critically read, discuss and evaluate methods and results of studies using AI in Medicine;
-an overview of state-of-the-art AI-powered tools in Medicine.

6716 000 000 87269 - 0 - AUTOMATION SOFTWARE AND DESIGN PATTERNS M	ING-INF/04	IINF-04/A	6	60/0/0/0	No	Voto

Ambito: 1144 - Attivita' formative affini o integrative C

Obiettivi: Il corso si propone di fornire una visione razionale delle principali problematiche, metodi, schemi di progettazione e ambienti di sviluppo per l'implementazione dei moderni sistemi di automazione. Il corso si concentrerà sulla generazione model-based di macchine a stati finiti, livelli di astrazione basati su Input e Output Bridges, Generic Devices e Generic Axes e sistemi di gestione dei guasti. Al termine del corso gli studenti sono in grado di padroneggiare aspetti progettuali di architetture software avanzate per macchine automatiche complesse, definendo modelli e soluzioni flessibili per i problemi più comuni, indipendentemente dall'architettura della macchina e dell'hardware di controllo.

Obiettivi inglese: The course aims to provide a rational view of the main principles, methodological issues, design patterns and integrated development environments involved in the implementation of modern automation systems. The course will focus on model driven generation of Finite State Machines, connection layers based on Input and Output Bridges, Generic Devices and Generic Axes and fault managment systems. At the end of the course students are able to master design aspects of advanced software architectures for complex automated machines, defining models and flexible solutions for common problems independently from the machine and hardware architecture.

6716 000 000 35425 - 0 - BIOIMMAGINI E INGEGNERIA CLINICA M	ING-INF/06	IBIO-01/A	6	60/0/0/0	No	Voto

Ambito: 1144 - Attivita' formative affini o integrative C

Obiettivi: Gestione e normativa delle apparecchiature biomediche. Sistemi informativi sanitari ed elementi di telemedicina. Il dimensionamento dei servizi sanitari. La diagnostica per immagini. Elaborazione di immagini biomediche: metodi di filtraggio e segmentazione. Visualizzazione assistita al calcolatore. Tecniche di realtà virtuale in biomedicina.

6716 000 000 35374 - 0 - BIOINGEGNERIA DELLA RIABILITAZIONE M	ING-IND/34	IBIO-01/A	6	60/0/0/0	No	Voto

Ambito: 1144 - Attivita' formative affini o integrative C

Obiettivi: Fornire allo Studente un quadro sulle problematiche della disabilità, gli ausili utilizzati e le tecniche per la valutazione funzionale con particolare riferimento alla neuroriabilitazione e neuroprotesi nel controllo della postura e del movimento, alla protesi e ortesi per arti superiori e inferiori, e al monitoraggio remoto, applicazioni domotiche e realtà virtuale.

6716 000 000 37465 - 0 - BIOMECCANICA COMPUTAZIONALE M	ING-IND/34	IBIO-01/A	6	60/0/0/0	No	Voto

Ambito: 1008 - A scelta dello studente D

Obiettivi: Lo studente, al termine del corso, acquisisce padronanza di strumenti computazionali avanzati per lo studio della biomeccanica dell'apparato muscoloscheletrico. Il corso richiama la meccanica dei solidi e il metodo agli elementi finiti, nonché dei metodi numerici per la modellazione ad elementi finiti di problemi non lineari quali grandi spostamenti, contatto, plasticità. Approfondisce lo sviluppo di strumenti computazionali avanzati per l'analisi del sistema muscolo-scheletrico intatto ed in presenza di dispositivi protesici, compresi i metodi per l'integrazione di dati provenienti da immagini con i modelli biomeccanici e per la cross-validazione con risultati ottenuti da sperimentazione in-vitro ed in-vivo. Lo studente sviluppa competenze nella formulazione e soluzione di problemi di biomeccanica strutturale e funzionale, e familiarizza con programmi commerciali diffusamente impiegati per risolvere questi problemi.

Obiettivi inglese: At the end of the module, the student masters advanced computational tools for studying the biomechanics of the musculoskeletal system. The course recalls the mechanics of solids, the finite element method, and numerical methods for finite element modelling of nonlinear problems such as large displacements, contact, and plasticity. The student will deepen the development of advanced computational tools for analysing the intact musculoskeletal system, also in the presence of prosthetic devices, including methods for integrating image data with biomechanical models and cross-validation with results obtained from in-vitro and in-vivo experimentation. The student will develop skills in formulating and solving structural and functional biomechanics problems and familiarise himself with commercial programs widely used to solve these problems.

6716 000 000 93798 - 0 - BIOMECCANICA SPERIMENTALE M	ING-IND/34	IBIO-01/A	6	60/0/0/0	No	Voto

Ambito: 1008 - A scelta dello studente D

Obiettivi: Lo studente si impadronisce degli strumenti computazionali avanzati per l'analisi del sistema muscolo-scheletrico intatto ed in presenza di dispositivi protesici. Impara ad integrare i dati provenienti da immagini con i modelli biomeccanici. Cross-validazione con risultati ottenuti da sperimentazione in-vitro ed in-vivo. Acquisisce comprensione teorico-pratica della meccanica dei continui e del metodo agli elementi finiti, nonché dei metodi numerici per la modellazione ad elementi finiti di problemi non lineari quali grandi spostamenti, contatto, plasticità, ecc. Familiarizza con programmi commerciali diffusamente impiegati. Sviluppa capacità di formulare e risolvere problemi di biomeccanica strutturale e funzionale.

6716 000 000 29145 - 0 - COMPLEMENTI DI ANALISI MATEMATICA M	MAT/05	MATH-03/A	6	60/0/0/0	No	Voto

Ambito: 1144 - Attivita' formative affini o integrative C

Obiettivi: Lo studente consolida la preparazione matematica con particolare riguardo alle equazioni differenziali ordinarie lineari e non lineari e alle equazioni a derivate parziali lineari del primo e del secondo ordine, applicando le più significative condizioni ai limiti per i vari tipi di equazioni. Approfondisce alcuni strumenti necessari per tale studio e che presentano anche un autonomo interesse, quali le serie di Fourier e le trasformate di Fourier e di Laplace.

6716 000 000 99195 - 0 - CYBER-PHYSICAL SYSTEMS PROGRAMMING M	ING-INF/05	IINF-05/A	6	60/0/0/0	No	Voto

Ambito: 1144 - Attivita' formative affini o integrative C

Obiettivi: Il corso fornisce allo studente una conoscenza di base delle architetture software e gli ambienti di sviluppo, programmazione e progettazione di sistemi cyber-fisici, con particolare enfasi alla coesistenza di task di controllo, processing di data stream, e comunicazione IoT con requisiti di real-time e cybersecurity. Nel corso lo studente impara a utilizzare compilatori, librerie, runtime e middleware per piattaforme e architetture eterogenee, dotate di processori multicore, co-processori e acceleratori HW e SW per il processing di stream di dati da sensori e verso attuatori.

Obiettivi inglese: The course provides the student with a basic knowledge of software architectures as well as the development, programming and design environments for cyber-physical systems, with particular emphasis on the coexistence of control tasks, data stream processing, and IoT communication with real-time and cybersecurity requirements. The student will learn to use compilers, libraries, runtimes and middleware for heterogeneous platforms and architectures, equipped with multicore processors, co-processors and HW and SW accelerators for the processing of data streams from sensors and towards actuators.

6716 000 000 99191 - 0 - DISPOSITIVI, CIRCUITI ED ALGORITMI PER IL CALCOLO QUANTISTICO M	ING-INF/01	IINF-01/A	6	60/0/0/0	No	Voto

Ambito: 211 - Ingegneria elettronica B

Obiettivi: Il corso introduce i concetti fondamentali per comprendere i sistemi hardware e software alla base del calcolo quantistico. Al termine, lo studente padroneggia i principi alla base del calcolo quantistico, la comprensione del modello di circuito quantistico, i principali algoritmi proposti, i concetti fisici alla base dell'implementazione dei sistemi hardware e le principali architetture elettroniche.

Obiettivi inglese: The course introduces the fundamental concepts for understanding the hardware and software systems underlying quantum computing. Upon completion, the student masters the principles underlying quantum computation, an understanding of the quantum circuit model, the main algorithms, the physical concepts underlying the implementation of hardware systems, and the main electronic architectures.

6716 000 000 35371 - 0 - ELABORAZIONE DI DATI E SEGNALI BIOMEDICI M	ING-INF/06	IBIO-01/A	6	60/0/0/0	No	Voto

Ambito: 1144 - Attivita' formative affini o integrative C

Obiettivi: Fornire allo Studente gli strumenti conoscitivi e metodologici per estrarre l'informazione utile da un segnale biomedico, interpretare i risultati e convalidare i descrittori ottenuti alla luce di elementi di conoscenza del sistema biologico coinvolto, produrre innovazione nell'ambito del miglioramento delle conoscenze fisiologiche, della produzione di nuove apparecchiature mediche "intelligenti", e della definizione di nuovi protocolli clinici di prevenzione, diagnosi e cura.

6716 000 000 37125 - 0 - ELECTROMAGNETIC COMPATIBILITY M	ING-IND/31	IIET-01/A	6	60/0/0/0	No	Voto

Ambito: 1144 - Attivita' formative affini o integrative C

Obiettivi: Il corso si propone di fornire la conoscenza delle principali problematiche relative alla compatibilità elettromagnetica delle apparecchiature elettriche e/o elettroniche. Vengono trattate la diafonia, le emissioni condotte e irradiate e l’immunità condotta e radiata, e ne sono ricavati modelli per l’analisi. Sono fornite le competenze per la soluzione di problemi di interferenza condotta e irradiata, con particolare riferimento ai filtri EMI, ai metodi e alle tecniche di schermatura elettromagnetica e alle misure in camera riverberante. Sono fornite inoltre le conoscenze dei fenomeni alla base della propagazione delle onde elettromagnetiche sia in mezzi illimitati sia guidata. Gli argomenti sono proposti agli studenti con particolare riferimento agli aspetti applicativi, accompagnando la teoria con attività di esercitazione numerica e di laboratorio.

Obiettivi inglese: The course provides the knowledge of the main concepts in the field of electromagnetic compatibility of electric/electronic devices. The main topics are crosstalk, conducted and radiated emissions with models for the analysis. The students are given an understanding for the solution of conducted and radiated electromagnetic interference, with particular reference to EMI filters, methods and techniques of electromagnetic shielding and measurement in reverberation chamber. The basic knowledge of electromagnetic wave propagation both in an arbitrary medium and in guiding structures is also provided. The topics are presented with reference to practical applications. Lectures are integrated with numerical and laboratory demos.

6716 000 000 93322 - 0 - HARDWARE-SOFTWARE DESIGN OF IOT SYSTEMS M	ING-INF/01	IINF-01/A	6	60/0/0/0	No	Voto

Ambito: 211 - Ingegneria elettronica B

Obiettivi: L'obiettivo principale del corso è fornire metodologie per l'analisi e la programmazione di sistemi elettronici embedded single-core e multi-core. Viene sottolineata l'importanza dei componenti software in tutti i sistemi elettronici. Le principali conoscenze e competenze da conseguire sono (i) una chiara comprensione delle architetture hardware embedded programmabili più comuni e delle piattaforme hardware-software; (ii) metodologie per l'analisi comparativa e approcci per stimare gli indicatori chiave di prestazione (KPI) come costi, prestazioni, efficienza energetica, per valutare quantitativamente l'utilizzo di una piattaforma hardware-software per un dominio applicativo (ad esempio automobilistico, di consumo, industriale) e per un'applicazione specifica; (iii) tecniche di sviluppo e verifica del software embedded, tenendo conto dei vincoli tipici e degli indicatori chiave di prestazione che differenziano i sistemi embedded dai sistemi informatici generici; (iv) metodi e strumenti di ottimizzazione del software per hardware embedded sia single-core che multi-core.

Obiettivi inglese: The main goal of the class is to provide methodologies for analyzing and programming singe-core and multi-core embedded electronic systems. The importance of software components in virtually all electronic systems is emphasized. The key learning outcomes are (i) a clear understanding of the most common programmable embedded hardware architectures and hardware-software platforms; (ii) methodologies for comparative analysis and approaches to estimate key performance indicators (KPIs) such as cost, performance, energy efficiency, to quantitatively assess the matching of a hardware-software platform for an application domain (e.g. automotive, consumer, industrial) and for a specific application; (iii) embedded software development and verification techniques, taking into account typical constraints and performance KPIs that differentiate embedded systems from general-purpose computing systems; (iv) hardware-aware software optimization methods and tools for both single-core and multi-core embedded hardware.

6716 000 000 84442 - 0 - HIGH FREQUENCY ELECTRONIC CIRCUITS M	ING-INF/01	IINF-01/A	6	60/0/0/0	No	Voto

Ambito: 211 - Ingegneria elettronica B

Obiettivi: The course deals with the analysis and design of high-frequency electronic circuits as those found in IoT, 5G and remote sensing applications. Students learn how high-frequency front-ends work, to state and evaluate the specifications of the main building blocks and to face the trade-offs involved in their design.

Obiettivi inglese: The course deals with the analysis and design of high-frequency electronic circuits as those found in IoT, 5G and remote sensing applications. Students learn how high-frequency front-ends work, to state and evaluate the specifications of the main building blocks and to face the trade-offs involved in their design.

6716 000 000 69661 - 0 - IMAGE PROCESSING AND COMPUTER VISION M	ING-INF/05	IINF-05/A	6	60/0/0/0	No	Voto

Ambito: 1144 - Attivita' formative affini o integrative C

Obiettivi: Introducing basic knowledge about algorithms, tools and systems for the management, processing and analysis of digital images. The main topics of the course are filtering aspects of digital images, algorithms for image processing, algorithms for segmentation and classification of objects in digital images. Theoretical aspects that are introduced in the course are then applied to the design and manufacturing capabilities of simple systems oriented to real world applications. At the end of the course students are able to master basic digital image processing techniques and know potentials of this technology in applicative research and industrial contexts.

Obiettivi inglese: Introducing basic knowledge about algorithms, tools and systems for the management, processing and analysis of digital images. The main topics of the course are filtering aspects of digital images, algorithms for image processing, algorithms for segmentation and classification of objects in digital images. Theoretical aspects that are introduced in the course are then applied to the design and manufacturing capabilities of simple systems oriented to real world applications. At the end of the course students are able to master basic digital image processing techniques and know potentials of this technology in applicative research and industrial contexts.

6716 000 000 69437 - 0 - NANOELETTRONICA M	ING-INF/01	IINF-01/A	6	60/0/0/0	No	Voto

Ambito: 211 - Ingegneria elettronica B

Obiettivi: Il corso si propone di fornire agli studenti che lo frequentano gli strumenti concettuali per affrontare lo studio dei dispositivi a dimensione nanometrica. La complessità delle equazioni quantiche del trasporto rende difficile lo sviluppo di modelli compatti e obbliga all'adozione di tecniche numeriche per la loro soluzione. Pertanto, il corso comprenderà nel proprio programma anche lo studio dei principali metodi numerici per la soluzione dell'equazione di Schrödinger a contorno sia chiuso che aperto, per il quale ha oggi assunto una grande popolarità il formalismo della funzione di Green di non equilibrio (NEGF). I dispositivi oggetto di studio comprenderanno, per la loro importanza preminente, i transitori ultrasottili di silicio su isolante (SOI), i fili quantici di silicio (NW-FET) e i dispositivi multi-gate (MG-FET), recentemente annunciati da Intel come componenti base del nodo tecnologico a 22 nanometri. Il corso esaminerà altresì dispositivi a eterostruttura basati su semiconduttori composti III-V, il cui interesse per le applicazioni digitali sta oggi aumentando a livello di ricerca per la realizzazione di componenti dotati di una transizione veloce fra lo stato di spegnimento e quello di accensione. Sono fra questi i transistori a effetto tunnel banda a banda e i super-reticoli (SL-FET) che, per la loro proprietà di filtraggio degli elettroni ad alta energia, rendono possibili pendenze inverse sotto soglia molto minori di (kBT/q) ln(10) = 60 mV/dec.

6716 000 000 93038 - 0 - OPTICAL TECHNOLOGIES FOR ELECTRICAL ENGINEERING M	ING-INF/02	IINF-02/A	6	120/0/0/0	No	Voto

Ambito: D

Obiettivi: Al termine del corso lo studente/la studentessa possiede familiarità con le caratteristiche di base delle Tecnologie Ottiche maggiormente utilizzate nell'area dell'Ingegneria Elettrica. Attraverso uno studio di componenti e dispositivi che si avvale di un approccio di tipo fisico e viene integrato da alcune esperienze di laboratorio, egli/ella è in grado di comprendere a fondo come le peculiarità di tali Tecnologie vengono sfruttate all'interno di Sistemi Elettrici e Smart Grid, per applicazioni di Telecomunicazioni, Monitoraggio e Sensoristica.

Obiettivi inglese: At the end of the course the student knows the basic characteristics of the Optical Technologies which are mainly utilized in the area of Electrical Engineering. Starting from a physically-based point of view, and taking advantage of some laboratory experiences, he/she deeply understands how the peculiar features of these Technologies are exploited within Electrical Systems and Smart Grids, for Communications, Monitoring and Sensing applications.

6716 000 000 81654 - 0 - PROGETTO DI CIRCUITI ANALOGICI AVANZATI M	ING-INF/01	IINF-01/A	6	60/0/0/0	No	Voto

Ambito: 1008 - A scelta dello studente B

Obiettivi: Illustrare il funzionamento e i criteri di progetto dei blocchi analogici fondamentali.

6716 000 000 B5665 - 0 - REAL TIME SYSTEMS AND PROGRAMMING FOR AUTOMATION M	ING-INF/05	IINF-05/A	12	120/0/0/0	No	Voto

Ambito: D

Obiettivi: Alla fine del corso lo studente:
- conosce le basi di Python e programmazione a oggetti;
- ha familiarità con i concetti fondamentali relativi all'organizzazione e al funzionamento dei moderni sistemi operativi con un'enfasi sui sistemi realtime per l'automazione;
- sa realizzare semplici applicazioni concorrenti che usino chiamate a sistema e meccanismi di sincronizzazione;
- sa analizzare progettare e implementare semplici applicazioni concorrenti realtime.

Obiettivi inglese: At the end of the course, the student:
- knows the basics of Python and object oriented programming;
- is familiar with the fundamental concepts underlying modern operating system organization and functioning, with an emphasis on real-time systems for automation;
- is able to realize simple concurrent applications using system calls and synchronization mechanisms;
- is able to analyze, design and implement simple real-time concurrent applications.

6716 000 000 B8311 - 0 - SECURITY OF DATA AND NEURAL PROCESSING M	ING-INF/01	IINF-01/A	6	60/0/0/0	No	Voto

Ambito: B

Obiettivi: The course provides a basic knowledge of the fundamental concepts, terminology and problems in cryptography as well as tools for assessing the security of data protection schemes commonly employed. It also provides high level requirements and design guidelines for typical blocks used in security-ensuring mechanisms.

Obiettivi inglese: The course provides a basic knowledge of the fundamental concepts, terminology and problems in cryptography as well as tools for assessing the security of data protection schemes commonly employed.
It also provides high level requirements and design guidelines for typical blocks used in security-ensuring mechanisms.

6716 000 000 40048 - 0 - SENSORI E TRASDUTTORI PER L'INDUSTRIA E L'AMBIENTE M	ING-INF/07	IMIS-01/B	6	60/0/0/0	No	Voto

Ambito: 1008 - A scelta dello studente D

Obiettivi: : Introdurre l'allievo al funzionamento ed alla caratterizzazione delle principali tipologie di sensori e trasduttori impiegati in ambito industriale e per rilevazioni ambientali; fornire indicazioni per un corretto interfacciamento fra questi dispositivi e le apparecchiature di controllo ed elaborazione che ne sfruttano i segnali; progettare ed implementare semplici sistemi di acquisizione ed elaborazione dei segnali forniti dai trasduttori.

Obiettivi inglese: The course instructs students in the operation and characterization of the main types of sensors and transducers used in the industrial sector and for environmental surveys; provides indications for correct interfacing between these devices and the control and processing equipment that exploit their signals; instructs students to the design and implementation of simple acquisition and processing systems for the signals supplied by the transducers.

6716 000 000 99192 - 0 - SISTEMI ELETTRONICI AD ALTA AFFIDABILITA' E RESILIENZA M	ING-INF/01	IINF-01/A	6	60/0/0/0	No	Voto

Ambito: 211 - Ingegneria elettronica B

Obiettivi: Studiare le tecniche di collaudo e progettazione orientata al collaudo di circuiti e sistemi integrati, e le strategie di progettazione di circuiti e sistemi integrati ad alta affidabilità e resilienza.

Obiettivi inglese: To study the techniques for testing and design for testability of integrated circuits and systems, and the design strategies for integrated circuits and systems with high reliability and resiliency.

6716 000 000 35424 - 0 - SISTEMI INTEGRATI PER L'ANALISI SPETTRALE M	ING-INF/01	IINF-01/A	6	60/0/0/0	No	Voto

Ambito: 211 - Ingegneria elettronica B

Obiettivi: Fornire le metodologie e le tecniche di progettazione di sistemi integrati per l'acquisizione, l'elaborazione e la classificazione di dati, segnali ed immagini mediante l'impiego di algoritmi e sistemi avanzati.

6716 000 000 87198 - 0 - STATISTICS AND ARCHITECTURES FOR BIG DATA PROCESSING M	ING-INF/01	IINF-01/A	6	60/0/0/0	No	Voto

Ambito: 211 - Ingegneria elettronica B

Obiettivi: The course provides students with a basic knowledge of problems and corresponding techniques of solutions implied by the ever increasing amount and complexity of the data available for analyses and decisions, i.e., the so called Big-Data (BD). The corresponding issues are tackled by multiple points of view: from the abstract characterization of the mathematical properties of BD, to the hardware architectures needed to process them.

Obiettivi inglese: The course provides students with a basic knowledge of problems and corresponding techniques of solutions implied by the ever increasing amount and complexity of the data available for analyses and decisions, i.e., the so called Big-Data (BD). The corresponding issues are tackled by multiple points of view: from the abstract characterization of the mathematical properties of BD, to the hardware architectures needed to process them.

6716 000 000 35372 - 0 - STRUMENTAZIONE BIOMEDICA M	ING-INF/06	IBIO-01/A	6	60/0/0/0	No	Voto

Ambito: 1144 - Attivita' formative affini o integrative C

Obiettivi: Analisi e progetto di semplici sistemi diagnostici. La sicurezza elettrica delle apparecchiature biomediche.

6716 000 000 87205 - 0 - TECHNOLOGIES AND APPLICATIONS OF WIRELESS POWER TRANSFER M	ING-INF/02	IINF-02/A	6	60/0/0/0	No	Voto

Ambito: 1008 - A scelta dello studente D

Obiettivi: The course aims at providing the rules for the analysis and design of a wireless link for the transmission of RF electromagnetic energy, exploiting both radiative techniques, by means of active antennas at the transmitter side and rectenna (rectifying antennas) at the receiver side, and non-radiative ones by inductive and capacitive coupling.The main non-linearities responsible for energy conversion, from RF to dc and vice versa, is studied and CAD tools based on the harmonic balancing technique are studied.The design process is also experimented by means of real-life systems based on simple energy reception systems for both radiation and reactive coupling mechanisms.

Obiettivi inglese: The course aims at providing the rules for the analysis and design of a wireless link for the transmission of RF electromagnetic energy, exploiting both radiative techniques, by means of active antennas at the transmitter side and rectenna (rectifying antennas) at the receiver side, and non-radiative ones by inductive and capacitive coupling.The main non-linearities responsible for energy conversion, from RF to dc and vice versa, is studied and CAD tools based on the harmonic balancing technique are studied.The design process is also experimented by means of real-life systems based on simple energy reception systems for both radiation and reactive coupling mechanisms.

6716 000 000 B5225 - 0 - TECHNOLOGY AND CHANGE IN GLOBAL POLITICS M	SPS/04	GSPS-02/A	6	30/0/0/0	No	Voto

Ambito: 1008 - A scelta dello studente D

Obiettivi: The course aims to provide students with advanced knowledge of the interplay between technology and international politics. The course looks at how technology has shaped change in the international system and how different states have used technology to advance their global positioning.
At the end of the course students is able to: a) discuss major transformations of the international system, b) understand how political factors can affect technological change.

Obiettivi inglese: The course aims to provide students with advanced knowledge of the interplay between technology and international politics. The course looks at how technology has shaped change in the international system and how different states have used technology to advance their global positioning.
At the end of the course students is able to: a) discuss major transformations of the international system, b) understand how political factors can affect technological change.

6716 000 000 73548 - 0 - WIRELESS SENSOR NETWORKS M	ING-INF/03	IINF-03/A	6	60/0/0/0	No	Voto	

Ambito: C

Obiettivi: This course introduces wireless communications for the Internet of Things (IoT). The course will describe the most used wireless technologies enabling the deployment of IoT networks. The theoretical part of the course will provide to students skills for designing an IoT network, accounting for connectivity, medium access control layer and routing issues, while considering the propagation environment where the network is located. Laboratory activities will allow students to use wireless devices to setup and run small IoT networks in a realistic environment and study their performance.

Obiettivi inglese: This course introduces wireless communications for the Internet of Things (IoT). The course will describe the most used wireless technologies enabling the deployment of IoT networks. The theoretical part of the course will provide to students skills for designing an IoT network, accounting for connectivity, medium access control layer and routing issues, while considering the propagation environment where the network is located. Laboratory activities will allow students to use wireless devices to setup and run small IoT networks in a realistic environment and study their performance.

Legenda:

CFU: crediti formativi universitari
TAF: tipologia attività formativa (A-di base; B-caratterizzanti; C-affini o integrative; F-ulteriori attività formative; D-a scelta autonoma dello studente; S- stages e tirocini presso imprese, enti pubblici o privati, ordini professionali; E-per la prova finale)
SSD: settore scientifico disciplinare
F/E/L/N: indica le ore Frontali/Esercitazioni/Laboratori/Ore di esercitazione e/o laboratorio tenute da non docenti
Freq.: segnala l'esistenza di un obbligo di frequenza
Ver.: indica la modalità di verifica del profitto finale
TIP.: indica la tipologia delle forme didattiche. Queste possono essere CON: convenzionali, E-L: in e-learning, MIX: miste, C/E: convenzionali e/o e-learning. Il corso di studio può definire annualmente una delle modalità.