ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

REGOLAMENTO DIDATTICO DEL CORSO

LM-27 [COMMUNICATIONS ENGINEERING]

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 Communications engineering, 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:

a) essere in possesso di una laurea in una delle seguenti 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.

b) Avere acquisito, altresì, 9 CFU in almeno 2 dei SSD ING-INF/01, ING-INF/02, ING-INF/03, e 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/08 Analisi numerica, MAT/09 Ricerca operativa;
- Gruppo 2: CHIM/07 Fondamenti chimici delle tecnologie, FIS/01 Fisica sperimentale, FIS/03 Fisica della materia, MAT/07 Fisica matematica;
- Gruppo 3: ING-INF/05 Sistemi di elaborazione delle informazioni, INF/01 Informatica.

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

La verifica dell'adeguatezza della personale preparazione, effettuata da parte di una Commissione, si intende assolta:
Per i candidati Laureati: Voto di laurea almeno pari a 85/110.

Per i candidati Laureandi:

- Totale dei CFU assegnati ad esami con voto non inferiore a 150;
- Media ponderata maggiore o uguale a 22/30.

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.

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.

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.

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

Art. 2 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. 3 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. 4 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. 5 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. 6 Attività formative a scelta dallo Studente

L'indicazione da parte dello Studente di attività formative a scelta guidata o autonoma deve essere presentata alla Segreteria Studenti entro i termini e secondo le modalità deliberati annualmente dall'Ateneo e resi note attraverso il Portale.
Lo Studente può indicare, come attività formative a scelta autonoma, uno o più insegnamenti/attività formative individuati dal Corso di Studio e previsti nel Piano Didattico.
Se lo Studente intende scegliere un insegnamento non previsto tra quelli consigliati dal Corso di Studio, deve fare richiesta al Consiglio stesso nei termini sopra indicati, affinché possa essere valutata la coerenza della scelta con il percorso formativo dello studente (DM 270/2004 art. 10, comma 5, lett. a).

Art. 7 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 ed è deliberato dal Consiglio di Corso di Studio, fino a concorrenza dei crediti dello stesso SSD previsti dall'Ordinamento didattico, nel rispetto dei relativi ambiti scientifico-disciplinari e della tipologia delle attività formative.
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. 8 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 SSD (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.
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 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. 10 Tirocinio curriculare

Il Corso di Studio prevede, a richiesta dello studente, la possibilità di svolgere un tirocinio curriculare secondo il Regolamento generale tirocini di Ateneo.

Art. 11 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

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.

***

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

Art. 1 Admission Requirements

To be admitted to the Programme, Applicants should hold an Italian bachelor's degree or a foreign degree evaluated as eligible.
Moreover, candidates must comply with the curriculum requirements as well as having a suitable prior preparation.

Curriculum requirements

To be admitted to the Second-cycle Degree in Telecommunications Engineering (T.E.), Applicants must:
c) Hold an Italian First-cycle degree of one of the following clusters:
- ex D.M. 270: Cluster L-8 – Information Engineering
- ex. D.M. 509/99: Cluster 9 - Information Engineering

or similar degrees complying with a previous set of rules and regulations.
b) Having done at least 9 CFU (ECTS credits) in at least 2 of the following teaching clusters: SSD ING-INF/01, ING-INF/02, ING-INF/03. Moreover, the First-cycle degree should contain at least 36 CFU overall in the following teaching clusters, with a minimum of 9 CFU in each:
- Group 1: MAT/02 Algebra, MAT/03 Geometria, MAT/05 Analisi matematica, MAT/06 Probabilità e statistica 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, MAT/07 Fisica matematica;
- Group 3: ING-INF/05 Sistemi di elaborazione delle informazioni, INF/01 Informatica.

Assessment of adequacy of the Applicants' prior preparation

Admission to the Programme shall be granted on condition the prior preparation is considered satisfactory.
1. For students holding a first cycle-degree, the adequacy of the academic preparation is met by the following requirement, which must be held according to the deadlines, rules and regulations set out yearly by the relevant University's Office:
- Graduation mark no lower than 85/110.

2. For graduating students, the adequacy of the academic preparation is met by both the following requirements, which must be held according to the deadlines, rules and regulations set out yearly by the relevant University's Office:
- Having earned at least 150 ECTS to which a mark has been given (i.e. not pass/fail exam) as well as
- Having a CPGA no lower than 22/30.

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.

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

Art. 2 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, cannot however ignore compliance with the regulations and guidelines defined by the competent bodies.
If the study plan provides for the choice of learning activities activated in a restricted access degree programme, admission to the same must also be previously approved by the restricted access degree programme Board based on criteria previously identified by it.

Art. 3 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. 4 Course Attendance — Specified order of the exams

A student is not entitled to access an exam if the teaching activity does not appear in their 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. 5 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. 6 Structure and outcome of the exams

Each teaching activity may have a different structure and outcome of the exam, e.g.:
• Written and oral exam, evaluation by numerical rating
• Oral-only exam, evaluation by numerical rating
• Written-only exam, evaluation by numerical rating
• Any of the above, evaluation by "Pass/Fail"

For each teaching activity the outcome of the exam is indicated in the Study Plan.
The structure of the exam is proposed by the teacher and is approved by the T.E. Degree Board or by the Programme Coordinator 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's subject. Intermediate exams on the course's subject are allowed, whose possible negative result does not influence the Student's access to the 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 the teaching activities held at CLA , the structure and outcome of the exam are specified by CLA.
For the internship activities, the procedures for the exam are defined in the running Internships Regulation.

Art. 7 Elective Learning Activities - Courses freely chosen by the student

In standard Study Plan, Students can select some courses within constrained sets of choices and other courses freely. For the latter, a list of suggested courses is provided. The Students' choices must be reported to the Student Office, within the deadlines and following the instructions defined on a year-by-year basis and published on the website.
As far as the free selections are concerned, Students can select either courses in the list of suggested ones, or among all the courses provided by the University of Bologna in accordance with the objectives of the Second- cycle Degree Programme. In the latter case, selections will be submitted to the T.E. Degree Board for approval.

Art. 8 Acknowledgement of credits acquired from Programmes belonging to the same class

This article applies only to Students owning an Italian Second-cycle Degree conforming to the provisions of the Ministry Decree n. 270/2004, belonging to the LM-29 class. The acknowledgement is carries out according to the rules stated in the Article 7 written in Italian ("Criteri di riconoscimento dei crediti acquisiti in Corsi di Studio della stessa classe").

Art. 9 Acknowledgement of credits acquired from Programmes belonging to a different class, from e- learning programs, or from international programs

The credits may be acknowledged by the T.E. Degree Board after an analysis based on the following criteria:
- Contents of the course whence the credits have been acquired
- Total number of teaching hours of the course
- Evaluation of the consistency of the sectors (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 Telecommunications Engineering Programme as indicated in the document entitled Ordinamento didattico del Corso di Studio.

Credits are acknowledged to the extent of those reported in this very document.
If, after recognition under the above rules, there are residual unused credits, the T.E. Degree Board may acknowledge them after evaluation of the specific case according to cultural affinity.

Art. 10 Acknowledgement of competencies and abilities not belonging to university education

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 credit threshold set forth on the Degree Teaching Regulation.
The activity may be recognized as long as it is deemed consistent with the degree's 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.

***

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-27-INGEGNERIA DELLE TELECOMUNICAZIONI**
Corso **6712-COMMUNICATIONS ENGINEERING**

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.
6712 000 000 82072 - 0 - ANTENNAS FOR WIRELESS SYSTEMS M		ING-INF/02	IINF-02/A		6	60/0/0/0	No	Voto
Ambito: 209 - Ingegneria delle telecomunicazioni				B				
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.								
6712 000 000 35167 - 0 - COMMUNICATION SYSTEMS: THEORY AND MEASUREMENT M		ING-INF/03	IINF-03/A		9	90/0/0/0	No	Voto
Ambito: 209 - Ingegneria delle telecomunicazioni				B				
Obiettivi: Al termine del corso, lo studente possiede conoscenze sulla trasmissione digitale con particolare riferimento ai sistemi wireless terrestri e satellitari. Nello specifico, lo studente è in grado di dimensionare un collegamento wireless, conosce le problematiche di modulazione e demodulazione digitale, gli effetti di propagazione anomala e relative tecniche per la loro mitigazione, incluse quelle multi-portante (OFDM) e multi-antenna (MIMO). In aggiunta, lo studente possiede conoscenze di simulazione e analisi in laboratorio dei sistemi di comunicazione digitali.								
Obiettivi inglese: At the end of the course, the student possesses knowledge of digital transmission with particular reference to terrestrial and satellite wireless systems. Specifically, the student is able to design a wireless link, understands the issues related to digital modulation and demodulation, the effects of anomalous propagation, and the related techniques for their mitigation, including multi-carrier (OFDM) and multi-antenna (MIMO) schemes. Additionally, the student has knowledge of simulation and laboratory analysis of digital communication systems.								

6712 000 000 87202 - 0 - COMMUNICATION THEORY AND CODING M	ING-INF/03	IINF-03/A	6	60/0/0/0	No	Voto

Ambito: 209 - Ingegneria delle telecomunicazioni B

Obiettivi: At the end of this course, the student will have knowledge of the essential constructs underpinning Communication Theory and its application in telecommunications systems. In particular, the student will master the fundamentals of Information Theory, Decision Theory, and Estimation Theory, as well as their practical application to Channel Coding for error protection.

Obiettivi inglese: At the end of this course, the student will have knowledge of the essential constructs underpinning Communication Theory and its application in telecommunications systems. In particular, the student will master the fundamentals of Information Theory, Decision Theory, and Estimation Theory, as well as their practical application to Channel Coding for error protection.

6712 000 000 82069 - 0 - ELECTROMAGNETIC PROPAGATION FOR WIRELESS SYSTEMS M	ING-INF/02	IINF-02/A	9	90/0/0/0	No	Voto

Ambito: 209 - Ingegneria delle telecomunicazioni B

Obiettivi: Mastery in engineering electromagnetic topics related to wave propagation. Knowledge of the main properties of radio propagation in real environment, expertise on path-loss models, multipath propagation modeling and radio channel wideband characterization. General comprehension of MIMO systems, diversity and spatial multiplexing techniques. Awareness of the main coverage and planning strategies for cellular radio, broadcasting and wireless systems. Assessment of wireless systems efficiency.

Obiettivi inglese: Mastery in engineering electromagnetic topics related to wave propagation. Knowledge of the main properties of radio propagation in real environment, expertise on path-loss models, multipath propagation modeling and radio channel wideband characterization. General comprehension of MIMO systems, diversity and spatial multiplexing techniques. Awareness of the main coverage and planning strategies for cellular radio, broadcasting and wireless systems. Assessment of wireless systems efficiency.

6712 000 000 87203 - 0 - MOBILE RADIO NETWORKS M	ING-INF/03	IINF-03/A	6	60/0/0/0	No	Voto

Ambito: 209 - Ingegneria delle telecomunicazioni B

Obiettivi: The student will be aware of the fundamentals of radio networks, covering aspects of the physical, data link and network layers, with specific reference to the evolution of mobile radio systems from GSM to 5G.

Obiettivi inglese: The student will be aware of the fundamentals of radio networks, covering aspects of the physical, data link and network layers, with specific reference to the evolution of mobile radio systems from GSM to 5G.

6712 000 000 82071 - 0 - NETWORK DESIGN M	ING-INF/03	IINF-03/A	6	60/0/0/0	No	Voto

Ambito: 209 - Ingegneria delle telecomunicazioni B

Obiettivi: Acquisition of skills in fundamental mathematical models and methodologies for performance evaluation and dimensioning of communication networks, and related applications to network design. Knowledge of main network models, quality of service mechanisms, control and management techniques and protocols for traffic and service engineering in evolving and emerging network scenarios, with applications to practical case studies.

Obiettivi inglese: Acquisition of skills in fundamental mathematical models and methodologies for performance evaluation and dimensioning of communication networks, and related applications to network design. Knowledge of main network models, quality of service mechanisms, control and management techniques and protocols for traffic and service engineering in evolving and emerging network scenarios, with applications to practical case studies.

6712 000 000 75477 - 0 - OPTICAL FIBER SYSTEMS M	ING-INF/02	IINF-02/A	6	60/0/0/0	No	Voto

Ambito: 209 - Ingegneria delle telecomunicazioni B

Obiettivi: Knowlegde of the operation of the building blocks of optical communication systems, aimed to their basic design in different realistic scenarios.

Obiettivi inglese: Knowlegde of the operation of the building blocks of optical communication systems, aimed to their basic design in different realistic scenarios.

6712 000 000 93330 - 0 - TRENDS IN COMMUNICATIONS M			3	0/0/30/0	No	Giudizio

Ambito: 1147 - Altre conoscenze utili per l'inserimento nel mondo del lavoro F

Obiettivi: Il corso mira ad estendere la conoscenza dei campi applicativi e delle necessità degli scenari in evoluzione nell'ambito delle telecomunicazioni, a mettere in pratica e sviluppare lavoro in squadra e capacità di interazione con il docente, a stimolare l'apprendimento attivo.

Obiettivi inglese: The course is intended to extend knowledge on application fields and needs of evolving communication scenarios, to practice and develop interaction skills with lecturer and team working, to stimulate active learning.

Gruppo: 2) Attività formative a scelta

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

Cfu min: 6 Cfu max: 6
Note: Scegli 6 crediti tra le seguenti attività formative:

Attività formativa	TIP	SSD	SSD 2024	TAF	CFU	ORE F/E/L/N	FREQ.	VER.
6712 000 000 73545 - 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: In the first part the student is supposed to learn the different types of graphs, their matrix representations, the related invariants and the problems which can find a model and solution in Graph Theory. In the second part, differential equations of the first and second order are studied.

Obiettivi inglese: In the first part the student is supposed to learn the different types of graphs, their matrix representations, the related invariants and the problems which can find a model and solution in Graph Theory. In the second part, differential equations of the first and second order are studied.

6712 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: Integer Programming is a very powerful tool for modeling combinatorial optimization problems arising in many branches of engineering, industry and resource allocation. The first part of this 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 discusses real-world applications.

Obiettivi inglese: Integer Programming is a very powerful tool for modeling combinatorial optimization problems arising in many branches of engineering, industry and resource allocation. The first part of this 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 discusses real-world applications.

Gruppo: 3) Altre attività formative

TAF: F Ambito: 1147 - Altre conoscenze utili per

Cfu min: 3 Cfu max: 3
Note: Scegli 3 crediti tra le seguenti attività formative:

Attività formativa	TIP	SSD	SSD 2024	TAF	CFU	ORE F/E/L/N	FREQ.	VER.
6712 000 000 99185 - 0 - CONNECTED VEHICLES M					3	30/0/0/0	No	Giudizio
Ambito:				F				

Obiettivi: Il corso darà una visione di insieme delle tecnologie wireless per i veicoli connessi e introdurrà i principali standard per comunicazioni a breve e lungo raggio. Sarà data particolare enfasi alle soluzioni che derivano dalle reti Wi-Fi e dalle reti cellulari applicate ai sistemi di trasporto intelligenti cooperativi.

Obiettivi inglese: The course will provide an overview of the wireless technologies for connected vehicles and introduce the main standards for long and short-range communications. Particular emphasis will be on the solutions deriving from Wi-Fi and cellular networks applied to cooperative intelligent transport systems.

6712 000 000 B5023 - 0 - CYBER-CREATIVITY AND INNOVATION M 3 0/0/30/0 No Giudizio

Ambito: 1147 - Altre conoscenze utili per l'inserimento nel mondo del lavoro F

Obiettivi: At the end of the course the student will gain knowledge of the following topics: The necessity for creativity and the emergence of generative artificial intelligence to enable the cyber-creative process. Learnings from the science of creativity studies. Principles and practical uses of Large Language Models. The DA VINCI Model & Method for the creative thinking process. Strategies and components for specific thinking stages. Innovation: hurdles and strategies for success. Practical applications to study cases.

Obiettivi inglese: At the end of the course the student will gain knowledge of the following topics: The necessity for creativity and the emergence of generative artificial intelligence to enable the cyber-creative process. Learnings from the science of creativity studies. Principles and practical uses of Large Language Models. The DA VINCI Model & Method for the creative thinking process. Strategies and components for specific thinking stages. Innovation: hurdles and strategies for success. Practical applications to study cases.

6712 000 000 87771 - 0 - LABORATORY OF NETWORKING T 3 0/0/30/0 No Giudizio

Ambito: 1147 - Altre conoscenze utili per l'inserimento nel mondo del lavoro F

Obiettivi: Students attending this course will consolidate their knowledge on theoretical and practical aspects of Communication and Computer Networks by means of hands-on experiments on real network equipment and services. The students will learn how to design and manage a typical corporate telecommunication network and will gain the basic competencies of a network administrator.

Obiettivi inglese: Students attending this course will consolidate their knowledge on theoretical and practical aspects of Communication and Computer Networks by means of hands-on experiments on real network equipment
and services. The students will learn how to design and manage a typical corporate telecommunication network and will gain the basic competencies of a network administrator.

6712 000 000 81799 - 0 - PROJECT MANAGEMENT AND SOFT SKILLS M 3 0/0/30/0 No Giudizio

Ambito: F

Obiettivi: The student will learn how to acquire the necessary skills to be a successful engineer. In particular, non-technical (also known as soft) skills are discussed; among them, emphasis will be given to inductive/deductive/analytical/design reasoning, to communication skills and employability. Moreover the student will learn how to use the basic tools of project management, including GANTT and PERT diagrams, workpackage breakdown, project cost estimation, and relevant aspects.

Obiettivi inglese: The student will learn how to acquire the necessary skills to be a successful engineer. In particular, non-technical (also known as soft) skills are discussed; among them, emphasis will be given to inductive/deductive/analytical/design reasoning, to communication skills and employability. Moreover the student will learn how to use the basic tools of project management, including GANTT and PERT diagrams, workpackage breakdown, project cost estimation, and relevant aspects.

Secondo Anno di Corso

Gruppo: 1) Prova finale

TAF: Ambito:

Cfu min: 24 Cfu max: 24

Note: Nell’ambito della prova finale, lo studente può scegliere di svolgere attività pratiche e di ricerca presso enti ed aziende esterne oppure presso laboratori interni all’Ateneo. Queste attività preparatorie possono essere inserite nella carriera per specificare la natura del lavoro svolto e registrate, a seconda dei casi, con un’idoneità o un voto.
Lo studente può quindi 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					0-24			

6712 000 000 86300 - 0 - FINAL EXAMINATION 24 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.

1.2) Gruppo B 0-24

6712 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.

6712 000 000 90054 - 0 - INTERNSHIP ABROAD FOR PREPARATION OF THE FINAL EXAMINATION 21 0/0/525/0 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.

6712 000 000 90377 - 0 - INTERNSHIP FOR PREPARATION FOR THE FINAL EXAMINATION 21 0/0/525/0 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.

6712 000 000 90053 - 0 - PREPARATION FOR THE FINAL EXAMINATION ABROAD 21 0/0/525/0 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: 2) Altre attività formative (Primo gruppo)

TAF: B Ambito: 209 - Ingegneria delle telecomunicazioni

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.

6712 000 000 B8397 - 0 - INTERNET OF THINGS M	ING-INF/03	IINF-03/A	6	60/0/0/0	No	Voto

Ambito: B

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.

6712 000 000 69494 - 0 - MULTIMEDIA SERVICES AND APPLICATIONS M	ING-INF/03	IINF-03/A	6	60/0/0/0	No	Voto

Ambito: 209 - Ingegneria delle telecomunicazioni B

Obiettivi: At the end of this course, the student will have knowledge of the main mechanisms and techniques for efficiently represent, transmit and manage multimedia contents by focusing on the main standards for voice, audio, image, video compression, on multimedia communication and networking protocols (VoIP, RTP), multimedia content distribution, cloud computing and multimedia services.

Obiettivi inglese: At the end of this course, the student will have knowledge of the main mechanisms and techniques for efficiently represent, transmit and manage multimedia contents by focusing on the main standards for voice, audio, image, video compression, on multimedia communication and networking protocols (VoIP, RTP), multimedia content distribution, cloud computing and multimedia services.

6712 000 000 82089 - 0 - RADIOPROTECTION AND SPECTRUM MANAGEMENT M	ING-INF/02	IINF-02/A	6	60/0/0/0	No	Voto

Ambito: 209 - Ingegneria delle telecomunicazioni B

Obiettivi: Provide the criteria for evaluation and control of electromagnetic fields in terms of interference and environmental impact.
This course aims at providing the basis of generation, propagation and interaction of electromagnetic fields with the environment and with biological systems, related to radio frequencies.
Students will learn how to identify the main transmission characteristics for industrial and residential electromagnetic sources (radio broadcasting systems, cellular mobile radio systems, household (electrical) appliance, industrial equipment, etc.) and the main bioelectromagnetics mechanisms of interaction. Moreover student will have gained the capacity to identify the suitable prediction models and measurement tools in order to survey, assess and mitigate electromagnetic field exposure. This course is designed in order to provide direction for radio systems frequency planning and radio spectrum efficiency use.

Obiettivi inglese: Provide the criteria for evaluation and control of electromagnetic fields in terms of interference and environmental impact.
This course aims at providing the basis of generation, propagation and interaction of electromagnetic fields with the environment and with biological systems, related to radio frequencies.
Students will learn how to identify the main transmission characteristics for industrial and residential electromagnetic sources (radio broadcasting systems, cellular mobile radio systems, household (electrical) appliance, industrial equipment, etc.) and the main bioelectromagnetics mechanisms of interaction. Moreover student will have gained the capacity to identify the suitable prediction models and measurement tools in order to survey, assess and mitigate electromagnetic field exposure. This course is designed in order to provide direction for radio systems frequency planning and radio spectrum efficiency use.

6712 000 000 82090 - 0 - SATELLITE COMMUNICATION AND NAVIGATION SYSTEMS M	ING-INF/03	IINF-03/A	6	60/0/0/0	No	Voto

Ambito: 209 - Ingegneria delle telecomunicazioni B

Obiettivi: Understanding of the architecture of satellite communication systems and satellite positioning systems and the main design principles and performance trade-off. The class covers the ground, space, and user segments fundamentals from a Communication Theory perspective.

Obiettivi inglese: Understanding of the architecture of satellite communication systems and satellite positioning systems and the main design principles and performance trade-off. The class covers the ground, space, and user segments fundamentals from a Communication Theory perspective.

6712 000 000 B8394 - 0 - WIRELESS CIRCUITS AND SYSTEMS FOR ENERGY AND DATA TRANSFER M	ING-INF/02	IINF-02/A	6	60/0/0/0	No	Voto

Ambito: B

Obiettivi: Il corso offre le conoscenze sia teoriche che pratiche per il progetto di componenti e circuiti a radiofrequenza, sia lineari che nonlineari, da impiegare nei moderni nodi sensori wireless a basso consumo. In particolare, si affronterà il progetto di antenne e la loro integrazione con trasmettitori e ricevitori. Le principali non linearità da impiegare verranno descritte in dettaglio e i loro effetti analizzati anche usando strumenti CAD basati sulla tecnica del bilanciamento armonico. Il corso fornirà anche competenze pratiche per il progetto di questi componenti attraverso lo sviluppo di attività di progetto collettivo.

Obiettivi inglese: The course provides theoretical and applicative skills for the design of radio frequency components and circuits, both linear and nonlinear, to be used in modern low-power wireless systems on bord of sensors. In particular, antennas integrated with transmitters and receivers will be designed. The main non-linearities involved will be studied and applied by CAD tools based on the harmonic balancing technique. The course will also provide practical skills for the design of these components by developing group projects.

Gruppo: 3) Attività formative a scelta (Secondo gruppo)

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

Cfu min: 6 Cfu max: 6
Note: Scegli 6 crediti tra le seguenti attività formative:

Attività formativa	TIP	SSD	SSD 2024	TAF	CFU	ORE F/E/L/N	FREQ.	VER.
6712 000 000 B8410 - 0 - DISTRIBUTED SYSTEMS AND NETWORK AUTOMATION M		ING-INF/05	IINF-05/A	C	6	60/0/0/0	No	Voto

Ambito:
Obiettivi: : Il corso intende fornire una solida base sui sistemi distribuiti e sulle loro applicazioni all'automazione di rete, coprendo concetti chiave come architetture, scalabilità e protocolli di comunicazione. Gli studenti acquisiranno inoltre competenze pratiche su tematiche quali la programmazione di socket, le API, la virtualizzazione e l'automazione di rete, con esperienze pratiche su piattaforme software open-source di riferimento.

Obiettivi inglese: This course intends to provide a solid foundation in distributed systems and their applications to network automation, covering key concepts like architectures, scalability, and communication protocols. Students will also gain practical skills in areas such as socket programming, APIs, virtualization and network automation, with hands-on experience on relevant open-source software platforms.

6712 000 000 84442 - 0 - HIGH FREQUENCY ELECTRONIC CIRCUITS M		ING-INF/01	IINF-01/A	C	6	60/0/0/0	No	Voto

Ambito: 1144 - Attivita' formative affini o integrative
Obiettivi: The course deals with the analysis and design of high frequency electronic circuits. Students learn how high frequency front-ends work, to state and evaluate the specifications of their main building blocks and to face the tradeoffs involved in their design.

Obiettivi inglese: The course deals with the analysis and design of high frequency electronic circuits. Students learn how high frequency front-ends work, to state and evaluate the specifications of their main building blocks and to face the tradeoffs involved in their design.

6712 000 000 84447 - 0 - INTRODUCTION TO COMPUTER ARCHITECTURES M		ING-INF/05	IINF-05/A	C	6	60/0/0/0	No	Voto

Ambito: 1144 - Attivita' formative affini o integrative
Obiettivi: Provide a vision of digital circuits at gate 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 gate and register transfer level. Overview of microprocessor and memory architectures. Basics of testing, performance and power consumption at system level.

6712 000 000 73545 - 0 - MATHEMATICAL METHODS M		MAT/05	MATH-03/A	C	6	60/0/0/0	No	Voto

Ambito: 1144 - Attivita' formative affini o integrative
Obiettivi: In the first part the student is supposed to learn the different types of graphs, their matrix representations, the related invariants and the problems which can find a model and solution in Graph Theory. In the second part, differential equations of the first and second order are studied.

Obiettivi inglese: In the first part the student is supposed to learn the different types of graphs, their matrix representations, the related invariants and the problems which can find a model and solution in Graph Theory. In the second part, differential equations of the first and second order are studied.

6712 000 000 95601 - 0 - OPTIMIZATION AND MACHINE LEARNING M		MAT/09	MATH-06/A	C	6	60/0/0/0	No	Voto

Ambito: 1144 - Attivita' formative affini o integrative
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.

6712 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: Integer Programming is a very powerful tool for modeling combinatorial optimization problems arising in many branches of engineering, industry and resource allocation. The first part of this 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 discusses real-world applications.

Obiettivi inglese: Integer Programming is a very powerful tool for modeling combinatorial optimization problems arising in many branches of engineering, industry and resource allocation. The first part of this 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 discusses real-world applications.

Gruppo: 4) Altre attività formative

TAF: F Ambito: 1147 - Altre conoscenze utili per

Cfu min: 6 Cfu max: 6

Note: Scegli 6 crediti tra le seguenti attività formative:

Attività formativa	TIP	SSD	SSD 2024	TAF	CFU	ORE F/E/L/N	FREQ.	VER.
6712 000 000 99185 - 0 - CONNECTED VEHICLES M					3	30/0/0/0	No	Giudizio

Ambito: F

Obiettivi: Il corso darà una visione di insieme delle tecnologie wireless per i veicoli connessi e introdurrà i principali standard per comunicazioni a breve e lungo raggio. Sarà data particolare enfasi alle soluzioni che derivano dalle reti Wi-Fi e dalle reti cellulari applicate ai sistemi di trasporto intelligenti cooperativi.

Obiettivi inglese: The course will provide an overview of the wireless technologies for connected vehicles and introduce the main standards for long and short-range communications. Particular emphasis will be on the solutions deriving from Wi-Fi and cellular networks applied to cooperative intelligent transport systems.

6712 000 000 B5023 - 0 - CYBER-CREATIVITY AND INNOVATION M					3	0/0/30/0	No	Giudizio

Ambito: 1147 - Altre conoscenze utili per l'inserimento nel mondo del lavoro F

Obiettivi: At the end of the course the student will gain knowledge of the following topics: The necessity for creativity and the emergence of generative artificial intelligence to enable the cyber-creative process. Learnings from the science of creativity studies. Principles and practical uses of Large Language Models. The DA VINCI Model & Method for the creative thinking process. Strategies and components for specific thinking stages. Innovation: hurdles and strategies for success. Practical applications to study cases.

Obiettivi inglese: At the end of the course the student will gain knowledge of the following topics: The necessity for creativity and the emergence of generative artificial intelligence to enable the cyber-creative process. Learnings from the science of creativity studies. Principles and practical uses of Large Language Models. The DA VINCI Model & Method for the creative thinking process. Strategies and components for specific thinking stages. Innovation: hurdles and strategies for success. Practical applications to study cases.

6712 000 000 82091 - 0 - INTERNSHIP IN ICT M	0				6	0/0/150/0	No	Giudizio

Ambito: F

Obiettivi: Activity in ICT companies subjected to approval of the internship commission

Obiettivi inglese: Activity in ICT companies subjected to approval of the internship commission

6712 000 000 B8304 - 0 - INTRODUCTION TO THE INTERNET OF THINGS T | 3 | 30/0/0/0 | No | Giudizio

Ambito: F

Obiettivi: This course deals with wireless communications for the Internet of Things (IoT). The course will be dedicated to the description of the main applications of the IoT and the available wireless technologies enabling the deployment of IoT networks. The student
will be capable of identifying relevant and business-oriented applications of the IoT and the most suitable technology for the deployment of the specific application. The course will include some team working, where students will discuss and share ideas on novel IoT applications and where they will have the opportunity to observe some real networks and measure their performance.

Obiettivi inglese: This course deals with wireless communications for the Internet of Things (IoT). The course will be dedicated to the description of the main applications of the IoT and the available wireless technologies enabling the deployment of IoT networks. The student
will be capable of identifying relevant and business-oriented applications of the IoT and the most suitable technology for the deployment of the specific application. The course will include some team working, where students will discuss and share ideas on novel IoT applications and where they will have the opportunity to observe some real networks and measure their performance.

6712 000 000 93179 - 0 - LABORATORY OF ADVANCED NETWORKING M | 3 | 0/0/30/0 | No | Giudizio

Ambito: 1147 - Altre conoscenze utili per l'inserimento nel mondo del lavoro F

Obiettivi: This course intends to consolidate the knowledge of theoretical aspects of Communication and Computer Networks with practical experience, by means of hands-on experiments on network equipment and services. The student will learn how to design and manage a typical corporate telecommunication network and will gain the basic competencies of a network administrator. Laboratory sessions constitute a relevant part of the course schedule and will be based on both physical and virtual equipment.

Obiettivi inglese: This course intends to consolidate the knowledge of theoretical aspects of Communication and Computer Networks with practical experience, by means of hands-on experiments on network equipment and services. The student will learn how to design and manage a typical corporate telecommunication network and will gain the basic competencies of a network administrator. Laboratory sessions constitute a relevant part of the course schedule and will be based on both physical and virtual equipment.

6712 000 000 73389 - 0 - LABORATORY OF HIGH FREQUENCY ELECTRONIC CIRCUIT DESIGN M | 3 | 0/0/30/0 | No | Giudizio

Ambito: 1147 - Altre conoscenze utili per l'inserimento nel mondo del lavoro F

Obiettivi: The student will learn the specific procedures for the analysis and the design of RF, microwave and millimeter-wave circuits by exploiting the most advanced CAD tools. Specific projects will be assigned to attendants. Each project consists 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).
Note: This course is taken from the Second-cycle Degree in Ingegneria Elettronica.

Obiettivi inglese: The student will learn the specific procedures for the analysis and the design of RF, microwave and millimeter-wave circuits by exploiting the most advanced CAD tools. Specific projects will be assigned to attendants. Each project consists 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).
Note: This course is taken from the Second-cycle Degree in Ingegneria Elettronica.

6712 000 000 98957 - 0 - LABORATORY OF MICROWAVE PHOTONICS T | 3 | 0/0/30/0 | No | Giudizio

Ambito: F

Obiettivi: Al termine del corso lo studente/la studentessa sarà consapevole di come i segnali Radio, a Microonde, ad Onde Millimetriche e a TeraHertz, possano essere efficacemente controllati e distribuiti sfruttando la loro opportuna interazione con i segnali Ottici. Saprà misurare i principali parametri di dispositivi e componenti ottici e RF, familiarizzando con la strumentazione appropriata. Sarà infine in grado di eseguire la caratterizzazione sperimentale di vari sistemi, le cui applicazioni spaziano dalle comunicazioni wireless e radar, fino ai sensori e alla radioastronomia, determinando i parametri di scattering di sistemi multiporta, acquisendo diagrammi di radiazione, valutando sistemi in fibra ottica per la remotizzazione di antenne e array di antenne, e verificando le prestazioni di antenne beamforming controllate otticamente.

Obiettivi inglese: At the end of the course the student will be aware of how Radio signals, as well as Microwave, Millimeter-Wave and THz-frequency signals, can be efficiently controlled and distributed exploiting their appropriate interaction with the Optical ones. He/she will know how to measure the main parameters of Optical and RF devices and components, becoming familiar with the appropriate instrumentation. The student will finally be able to perform the experimental characterization of various systems, whose applications range from wireless communications and radars, up to sensors and radio astronomy, which will comprise the determination of multi-port scattering parameters, the acquisition of antennas radiation patterns, the evaluation of optical fiber systems for the remotization of antennas / array of antennas, and the performance assessment of optically controlled beamforming antennas.

6712 000 000 87771 - 0 - LABORATORY OF NETWORKING T		3	0/0/30/0	No	Giudizio

Ambito: 1147 - Altre conoscenze utili per l'inserimento nel mondo del lavoro F

Obiettivi: Students attending this course will consolidate their knowledge on theoretical and practical aspects of Communication and Computer Networks by means of hands-on experiments on real network equipment and services. The students will learn how to design and manage a typical corporate telecommunication network and will gain the basic competencies of a network administrator.

Obiettivi inglese: Students attending this course will consolidate their knowledge on theoretical and practical aspects of Communication and Computer Networks by means of hands-on experiments on real network equipment
and services. The students will learn how to design and manage a typical corporate telecommunication network and will gain the basic competencies of a network administrator.

6712 000 000 B8431 - 0 - LABORATORY OF VEHICULAR NETWORKS M		3	0/0/30/0	No	Giudizio

Ambito: F

Obiettivi: The course guides the students through the design and implementation of simulations of wireless networks, with special focus on vehicular networks. Through the use open-source software, students will create realistic scenarios and assess the performance of wireless communications in examples of automotive use cases.

Obiettivi inglese: The course guides the students through the design and implementation of simulations of wireless networks, with special focus on vehicular networks. Through the use open-source software, students will create realistic scenarios and assess the performance of wireless communications in examples of automotive use cases.

6712 000 000 81799 - 0 - PROJECT MANAGEMENT AND SOFT SKILLS M		3	0/0/30/0	No	Giudizio

Ambito: F

Obiettivi: The student will learn how to acquire the necessary skills to be a successful engineer. In particular, non-technical (also known as soft) skills are discussed; among them, emphasis will be given to inductive/deductive/analytical/design reasoning, to communication skills and employability. Moreover the student will learn how to use the basic tools of project management, including GANTT and PERT diagrams, workpackage breakdown, project cost estimation, and relevant aspects.

Obiettivi inglese: The student will learn how to acquire the necessary skills to be a successful engineer. In particular, non-technical (also known as soft) skills are discussed; among them, emphasis will be given to inductive/deductive/analytical/design reasoning, to communication skills and employability. Moreover the student will learn how to use the basic tools of project management, including GANTT and PERT diagrams, workpackage breakdown, project cost estimation, and relevant aspects.

6712 000 000 75493 - 0 - PROTOCOLS AND ARCHITECTURES FOR SPACE NETWORKS M	0	3	0/0/30/0	No	Giudizio

Ambito: F

Obiettivi: The student will learn how to solve through the use of DTN architectures (Delay-Tolerant Networking, RFC 4838) and the Bundle Protocol (RFC 5050) problems set by “challenged networks”.

Obiettivi inglese: The student will learn how to solve through the use of DTN architectures (Delay-Tolerant Networking, RFC 4838) and the Bundle Protocol (RFC 5050) problems set by “challenged networks”.

Gruppo: 5) Attività formative a scelta libera consigliate

TAF: D Ambito: 1008 - A scelta dello studente

Cfu min: 12 Cfu max: 12

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

Attività formativa	TIP	SSD	SSD 2024	TAF	CFU	ORE F/E/L/N	FREQ.	VER.
6712 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.

6712 000 000 B5023 - 0 - CYBER-CREATIVITY AND INNOVATION M			3	0/0/30/0	No	Giudizio

Ambito: 1147 - Altre conoscenze utili per l'inserimento nel mondo del lavoro F

Obiettivi: At the end of the course the student will gain knowledge of the following topics: The necessity for creativity and the emergence of generative artificial intelligence to enable the cyber-creative process. Learnings from the science of creativity studies. Principles and practical uses of Large Language Models. The DA VINCI Model & Method for the creative thinking process. Strategies and components for specific thinking stages. Innovation: hurdles and strategies for success. Practical applications to study cases.

Obiettivi inglese: At the end of the course the student will gain knowledge of the following topics: The necessity for creativity and the emergence of generative artificial intelligence to enable the cyber-creative process. Learnings from the science of creativity studies. Principles and practical uses of Large Language Models. The DA VINCI Model & Method for the creative thinking process. Strategies and components for specific thinking stages. Innovation: hurdles and strategies for success. Practical applications to study cases.

6712 000 000 B8397 - 0 - INTERNET OF THINGS M	ING-INF/03	IINF-03/A	6	60/0/0/0	No	Voto

Ambito: B

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.

6712 000 000 B2127 - 0 - MACHINE LEARNING AND DEEP LEARNING I.C.			12			Voto
Modulo integrato: 95631 - MACHINE LEARNING AND DATA MINING	ING-INF/05	IINF-05/A	6	64/0/0/0	No	

Ambito: B

Obiettivi: Al termine del corso, lo studente conosce e comprende: - i principi e i più importanti casi d'uso degli algoritmi di Machine Learning utilizzati per estrarre informazioni interessanti da grandi quantità di dati; - le specificità dei processi di analisi e manipolazione di Big Data - i principali framework disponibili per Big Data. - In particolare, lo studente è in grado di: - progettare un processo di Data Mining nelle sue principali fasi - scegliere i metodi di Machine Learning più adeguati al processo - valutare la qualità del risultato per supportare decisioni strategiche e operative.

Obiettivi inglese: At the end of the course the student knows and understands: - the motivation and the components of the Data Mining process; - the general concepts, technologies and methodologies of Data Warehouse, OLAP and Data Lake, as enabling factors of the Data Mining process; - the principles and the most relevant use cases of a wide set of Machine Learning algorithms which are used to extract relevant and actionable information from large amounts of data. At the end of the course the student is able to: - design the main steps of a Data Mining process - choose the Machine Learning methods best suited for the process - evaluate the quality of the result in order to support strategic and operational decisions.

Modulo integrato: 91250 - DEEP LEARNING	INF/01	INFO-01/A	6	48/0/0/0	No	

Ambito: B

Obiettivi: Al termine dell'attività formativa, lo studente comprende le idee fondamentali, gli sviluppi recenti e le applicazioni potenziali dei sistemi neuronali (artificiali) profondi. Lo studente comprende tecniche supervisionate e non supervisionate, topologie neurali di base, metodi per visualizzare e capire il comportamento delle reti neurali, tecniche antagoniste e generative, apprendimento per rinforzo e reti ricorrenti. Lo studente è capace di applicare tali tecnologie a risolvere problemi di classificazione in domini realistici.

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.

6712 000 000 73545 - 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: In the first part the student is supposed to learn the different types of graphs, their matrix representations, the related invariants and the problems which can find a model and solution in Graph Theory. In the second part, differential equations of the first and second order are studied.

Obiettivi inglese: In the first part the student is supposed to learn the different types of graphs, their matrix representations, the related invariants and the problems which can find a model and solution in Graph Theory. In the second part, differential equations of the first and second order are studied.

6712 000 000 69494 - 0 - MULTIMEDIA SERVICES AND APPLICATIONS M	ING-INF/03	IINF-03/A	6	60/0/0/0	No	Voto

Ambito: 209 - Ingegneria delle telecomunicazioni B

Obiettivi: At the end of this course, the student will have knowledge of the main mechanisms and techniques for efficiently represent, transmit and manage multimedia contents by focusing on the main standards for voice, audio, image, video compression, on multimedia communication and networking protocols (VoIP, RTP), multimedia content distribution, cloud computing and multimedia services.

Obiettivi inglese: At the end of this course, the student will have knowledge of the main mechanisms and techniques for efficiently represent, transmit and manage multimedia contents by focusing on the main standards for voice, audio, image, video compression, on multimedia communication and networking protocols (VoIP, RTP), multimedia content distribution, cloud computing and multimedia services.

6712 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.

6712 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: Integer Programming is a very powerful tool for modeling combinatorial optimization problems arising in many branches of engineering, industry and resource allocation. The first part of this 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 discusses real-world applications.

Obiettivi inglese: Integer Programming is a very powerful tool for modeling combinatorial optimization problems arising in many branches of engineering, industry and resource allocation. The first part of this 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 discusses real-world applications.

6712 000 000 81799 - 0 - PROJECT MANAGEMENT AND SOFT SKILLS M			3	0/0/30/0	No	Giudizio

Ambito: F

Obiettivi: The student will learn how to acquire the necessary skills to be a successful engineer. In particular, non-technical (also known as soft) skills are discussed; among them, emphasis will be given to inductive/deductive/analytical/design reasoning, to communication skills and employability. Moreover the student will learn how to use the basic tools of project management, including GANTT and PERT diagrams, workpackage breakdown, project cost estimation, and relevant aspects.

Obiettivi inglese: The student will learn how to acquire the necessary skills to be a successful engineer. In particular, non-technical (also known as soft) skills are discussed; among them, emphasis will be given to inductive/deductive/analytical/design reasoning, to communication skills and employability. Moreover the student will learn how to use the basic tools of project management, including GANTT and PERT diagrams, workpackage breakdown, project cost estimation, and relevant aspects.

6712 000 000 82089 - 0 - RADIOPROTECTION AND SPECTRUM MANAGEMENT M	ING-INF/02	IINF-02/A	6	60/0/0/0	No	Voto

Ambito: 209 - Ingegneria delle telecomunicazioni B

Obiettivi: Provide the criteria for evaluation and control of electromagnetic fields in terms of interference and environmental impact.
This course aims at providing the basis of generation, propagation and interaction of electromagnetic fields with the environment and with biological systems, related to radio frequencies.
Students will learn how to identify the main transmission characteristics for industrial and residential electromagnetic sources (radio broadcasting systems, cellular mobile radio systems, household (electrical) appliance, industrial equipment, etc.) and the main bioelectromagnetics mechanisms of interaction. Moreover student will have gained the capacity to identify the suitable prediction models and measurement tools in order to survey, assess and mitigate electromagnetic field exposure. This course is designed in order to provide direction for radio systems frequency planning and radio spectrum efficiency use.

Obiettivi inglese: Provide the criteria for evaluation and control of electromagnetic fields in terms of interference and environmental impact.
This course aims at providing the basis of generation, propagation and interaction of electromagnetic fields with the environment and with biological systems, related to radio frequencies.
Students will learn how to identify the main transmission characteristics for industrial and residential electromagnetic sources (radio broadcasting systems, cellular mobile radio systems, household (electrical) appliance, industrial equipment, etc.) and the main bioelectromagnetics mechanisms of interaction. Moreover student will have gained the capacity to identify the suitable prediction models and measurement tools in order to survey, assess and mitigate electromagnetic field exposure. This course is designed in order to provide direction for radio systems frequency planning and radio spectrum efficiency use.

6712 000 000 82090 - 0 - SATELLITE COMMUNICATION AND NAVIGATION SYSTEMS M	ING-INF/03	IINF-03/A	6	60/0/0/0	No	Voto

Ambito: 209 - Ingegneria delle telecomunicazioni B

Obiettivi: Understanding of the architecture of satellite communication systems and satellite positioning systems and the main design principles and performance trade-off. The class covers the ground, space, and user segments fundamentals from a Communication Theory perspective.

Obiettivi inglese: Understanding of the architecture of satellite communication systems and satellite positioning systems and the main design principles and performance trade-off. The class covers the ground, space, and user segments fundamentals from a Communication Theory perspective.

6712 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.

6712 000 000 B8394 - 0 - WIRELESS CIRCUITS AND SYSTEMS FOR ENERGY AND DATA TRANSFER M	ING-INF/02	IINF-02/A	6	60/0/0/0	No	Voto

Ambito: B

Obiettivi: Il corso offre le conoscenze sia teoriche che pratiche per il progetto di componenti e circuiti a radiofrequenza, sia lineari che nonlineari, da impiegare nei moderni nodi sensori wireless a basso consumo. In particolare, si affronterà il progetto di antenne e la loro integrazione con trasmettitori e ricevitori. Le principali non linearità da impiegare verranno descritte in dettaglio e i loro effetti analizzati anche usando strumenti CAD basati sulla tecnica del bilanciamento armonico. Il corso fornirà anche competenze pratiche per il progetto di questi componenti attraverso lo sviluppo di attività di progetto collettivo.

Obiettivi inglese: The course provides theoretical and applicative skills for the design of radio frequency components and circuits, both linear and nonlinear, to be used in modern low-power wireless systems on bord of sensors. In particular, antennas integrated with transmitters and receivers will be designed. The main non-linearities involved will be studied and applied by CAD tools based on the harmonic balancing technique. The course will also provide practical skills for the design of these components by developing group projects.

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.