ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

REGOLAMENTO DIDATTICO DEL CORSO

LM-28 [ELECTRIC VEHICLE 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 l'ammissione al Corso di Studio in Electric Vehicle Engineering occorre essere in possesso di una laurea o del diploma universitario di durata triennale, ovvero di altro titolo di studio conseguito all'estero, riconosciuto idoneo.
Occorre, altresì, il possesso di requisiti curriculari e il superamento di una verifica dell'adeguatezza della personale preparazione.

Requisiti curriculari

Per l'ammissione al Corso di Studio è necessario:

1. Avere conseguito la Laurea di primo o secondo livello in una delle seguenti classi, o possedere altro titolo di studio conseguito all'estero, riconosciuto idoneo:

- Ordinamento D.M. 270/2004: o L-9 Ingegneria Industriale
o L-8 Ingegneria dell'Informazione
o LM-25 Ingegneria dell'Automazione
o LM-27 Ingegneria delle Telecomunicazioni o LM-28 Ingegneria Elettrica
o LM-29 Ingegneria Elettronica
o LM-30 Ingegneria Energetica e Nucleare

- Ordinamento D.M. 509/99:
o classe 10 Ingegneria Industriale
o classe 9 Ingegneria dell'Informazione
o classe 29/S Ingegneria dell'Automazione
o classe 30/S Ingegneria delle Telecomunicazioni o classe 31/S Ingegneria Elettrica
o classe 32/S Ingegneria Elettronica
o classe 33/S Ingegneria Energetica e Nucleare

2. Avere acquisito almeno 15 CFU nei seguenti Settori Scientifico Disciplinari:

- ING-IND/31
- ING-IND/32
- ING-IND/33
- ING-INF/07

Verifica dell'adeguatezza della personale preparazione

L'ammissione al corso di laurea magistrale è subordinata al superamento di una verifica dell'adeguatezza della personale preparazione che avverrà secondo le modalità definite annualmente dal Dipartimento nel bando di ammissione e rese note nel sito del corso di studio.
È richiesta la conoscenza della lingua inglese non inferiore al livello B2 del Quadro comune europeo di riferimento per la conoscenza delle lingue.
Per l'accesso al corso è necessario possedere conoscenze nella lingua italiana equivalenti ad un livello non inferiore al B2 del QCER.
Gli studenti stranieri non in possesso di questo requisito dovranno inserire nel proprio piano di studi attività formative finalizzate al raggiungimento del livello richiesto.

Modalità di ammissione

Il corso di laurea magistrale è a numero programmato a livello locale.
Il numero di studenti iscrivibili e le modalità di svolgimento della selezione saranno resi pubblici ogni anno con il relativo bando di concorso.

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

Lo studente può indicare come attività formative autonomamente scelte dallo studente una o più attività formative tra quelle che il Consiglio di Corso di studio individua annualmente e rende note tramite Portale di Ateneo.
Se lo studente intende sostenere un esame relativo ad una attività non prevista tra quelle individuate dal Consiglio di Corso di studio, deve fare richiesta al Consiglio di Corso nei termini previsti annualmente e resi noti tramite pubblicazione sul Portale di Ateneo. Il Consiglio valuterà la coerenza della scelta con il percorso formativo dello studente.
Lo studente può fare richiesta di inserimento di un esame erogato da uno degli Atenei consorziati MUNER, che sarà valutata dal Consiglio di Corso di studio in termini di coerenza con il percorso formativo dello studente.

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.
Il riconoscimento è relativo ad insegnamenti impartiti in lingua inglese o alle attività formative svolte in tale lingua.

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;
- valutazione della congruità dei settori scientifico disciplinari 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, residuino crediti non utilizzati, il Consiglio di Corso di studio può riconoscerli valutando il caso concreto sulla base delle affinità didattiche e culturali.
Con riferimento ai corsi di studio erogati in lingua inglese dall'italiano, il riconoscimento è relativo ad insegnamenti impartiti o alle attività formative svolte in lingua inglese.

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, 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. 11 Prova finale

Caratteristiche della prova finale
La prova finale è pubblica e consiste nella elaborazione e discussione di una tesi scritta in lingua inglese, redatta in modo originale dallo studente con la supervisione di un docente relatore.
In particolare, può consistere in:

- presentazione e discussione di un progetto originale che può comprendere una parte sperimentale e di laboratorio, sviluppato sotto la supervisione di un docente relatore;
- presentazione e discussione dell'attività svolta presso aziende o enti esterni, identificati sulla base di apposite convenzioni e anche durante un periodo di tirocinio per tesi opportunamente previsto oppure presso un laboratorio di ricerca dell'Università o di altri enti di ricerca pubblici o privati, con la supervisione di un docente e, quando opportuno, di un referente segnalato dalle aziende o dagli enti esterni.

Il lavoro deve essere svolto con adeguato livello di autonomia e capacità di analisi critica, e deve essere esposto e discusso dal candidato con appropriate capacità comunicative.

Modalità di svolgimento della prova finale
Per l'ammissione alla prova finale lo studente deve avere acquisito tutti i crediti formativi per le attività diverse dalla prova finale, distribuiti nelle differenti tipologie secondo le indicazioni del piano didattico.
Dall'elaborato di tesi deve emergere padronanza degli argomenti trattati e degli strumenti teorici e tecnici utilizzati dal candidato, nonché coerenti con gli obiettivi del Corso di Studio. L'argomento della relazione è svolto sotto la supervisione di un Docente di attività formative previste nella programmazione didattica dell'Ateneo.
Le Commissioni sono nominate dal Coordinatore del Consiglio di Corso di Studio.
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

Art. 1 Admission Requirements

Admission to the Second-cycle Degree Programme in Electric Vehicle Engineering is subject to the possession of a three-year university degree or other suitable qualification obtained abroad.
Moreover, candidates must meet the curricular requirements and pass a test to assess their personal competences and skills.

Curriculum requirements.
Admission to the Programme is also subjected to the possession of the following curricular requirements:

1. A First-cycle Degree or Second-cycle Degree in one of the following classes, or other suitable qualification obtained abroad:
- ex Italian Ministerial Decree n. 270/2004: L-9, L-8, LM-25 Ingegneria dell'Automazione, LM-27 Ingegneria delle Telecomunicazioni, LM-28 Ingegneria Elettrica, LM-29 Ingegneria Elettronica, LM-30 Ingegneria Energetica e Nucleare.
- ex Italian Ministerial Decree n. 509/1999: class 10, class 9, 29/S Ingegneria dell'Automazione, 30/S Ingegneria delle Telecomunicazioni, 31/S Ingegneria Elettrica, 32/S Ingegneria Elettronica, 33/S Ingegneria Energetica e Nucleare.

2. Having acquired at least 15 CFU credits in the following subject areas:
- SSD ING-IND/31
- SSD ING-IND/32
- SSD ING-IND/33
- SSD ING-INF/07

Verification of the adequacy of personal preparation.
Admission to the Master's Degree Programme is subject to passing an assessment of the adequacy of personal preparation, which will take place according to the criteria defined in the Degree Programme teaching regulations.
To access the course, students should prove an English proficiency no lower than the CEFR's B2 level.
The knowledge of Italian language at level B2 of the CEFR is also required. Foreign students not meeting this requirement will have to include in their study plan training activities aiming at achieving it.

Admission criteria
The Programme adopts the *numerus clausus* (according to Italian Law 264/99 – art. 2) on account of the resources available. A “Call for Applications” will set out yearly the selection procedure and the number of students that can be admitted.

Art.2 Individual study plans

It is possible to submit individual study plans according to 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 provides for the choice of learning activities activated in a restricted access degree programme, admission to such activities must also be previously approved by the restricted access Degree Programme Board, based on the criteria previously defined.

Art. 3 Teaching methods and typology

The teaching plan indicates how teaching activities are carried out and their partition into hours of frontal teaching, practical exercises or internships, as well as the type of teaching forms.
Any further information in this regard will be published annually on the University Portal.

Art. 4 Flexible path

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, according to the procedures defined in the University Teaching Regulations.
The training activities included in the teaching plan may be replaced in case of deactivation, in order to guarantee the quality and sustainability of the educational offer.

Art. 5 Structure of the exams

The teaching plan envisages training activities to be concluded with an exam, whose assessment must be expressed through a mark or a pass/fail evaluation.
The methods for carrying out such exams are established every year by the Degree Board when presenting the teaching program and made known to students before the start of lessons through the University Portal.

Art. 6 Learning activities chosen by the Student

As far as elective courses are concerned, Students can pick and choose those suggested by the Degree board and published on the University Portal.
To choose an exam not included among those suggested, students must submit a request to the Degree Board within the deadlines set every year and made known through the publication on the University Portal. The Board will evaluate the consistency of the choice with the student's educational path.
Students can also choose exams provided by one of the MUNER member universities. The Board will evaluate the consistency of the choice with the student's educational path.

Art. 7 Criteria for the recognition of credits acquired in Degree Programmes in the same class

In order to boost student's mobility, University credits might be recognized by the Degree Board. Such recognition shall take place up to the number of credits indicated for the same subject area as laid down in the Degree Teaching Regulation, in compliance with the related subject area and the type of learning activities.
Should credits go unused upon the recognition carried out according to this Degree Regulation, the Degree Board may recognize them on a case-by-case basis, considering teaching as well as cultural affinities.
The recognition relates to courses taught in English or training activities carried out in that language.

Art. 8 Criteria for the recognition of credits acquired within degree programmes in different classes, from telematic universities or international degree programmes

The acquired credits are recognized by the Degree Board according to the following criteria:
- analysis of the course contents;
- assessment of the coherence of the scientific-disciplinary fields and the contents of the learning activities in which the student has acquired the credits with the specific learning outcomes of the study programme and the individual learning activities to be recognized, in any case pursuing the aim of promoting student mobility.

The credits are recognized up to the maximum number of university credits laid down in the Degree Programme Teaching Regulation.
Should credits go unused upon the recognition carried out according to this Degree Regulation, the Degree Board may recognize them on a case-by-case basis, taking into account teaching as well as cultural affinities.

Art. 9 Criteria for the recognition of extra-university competencies and skills

Competencies acquired outside the University may be recognized when provided for by current legislation. The request for recognition will be evaluated by the Degree Board taking into account the maximum number of recognizable credits set in the course's teaching regulations.
Recognition may occur if the activity is deemed consistent with the specific educational objectives of the course of study.

Art. 10 Curricular internship

Upon student's request, the Degree Board may authorize an internship for the purposes of the final examination or in any case linked to a project aiming to develop learning and academic skills. The internship shall abide by the procedures laid down in the running University's Teaching Regulation, as well as by international mobility programmes and EU laws.

Art. 11 Final exam: structure and admission

Structure of the final exam
The final exam is public and consists of the preparation and discussion of a thesis written in English, written in an original way by the student under the supervision of a supervisor. The final exam may imply:

- Presenting and discussing an original project which can include research and laboratory findings, developed under a supervisor.
- Presenting and discussing activities performed in a company, external institution, external or internal research laboratory, according to an agreement with the University of Bologna that can foresee internship-based final project. In these cases, a supervising professor must oversee student's experience and, if required, an external tutor shall be appointed.

The final exam must show the Student's ability to master the subject, their attitude to work autonomously, and high-level communication skills.

Carrying out of the final exam
To access the final exam, students must acquire all the credits in the teaching activities (apart from the final exam) distributed into the different types as defined herein below in the Study Plan.
The final work must demonstrate student's ability to master the topics addressed as well as the technical tools deployed, which must be coherent with the Programme's goals. The final project shall be carried out under the supervision of a lecturer in charge of teaching activities foreseen in the University's teaching planning.
Graduation commission shall be appointed by the Deegree Coordinator.
The evaluation of the final exam is expressed in 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-28-INGEGNERIA ELETTRICA**
Corso **6713-ELECTRIC VEHICLE ENGINEERING**

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.
6713 000 000 93729 - 0 - ADVANCED ELECTRIC DRIVES AND SENSORS M I.C.					12			Voto
Modulo integrato: 91340 - ADVANCED ELECTRIC DRIVES M		ING-IND/32	IIND-08/A		6	60/0/0/0	No	
Ambito: 210 - Ingegneria elettrica				B				

Obiettivi: The course aims to provide a deep knowledge on the vector control of AC electric motors. At first, starting from dynamic equation, a control model on d-q axes of the following AC machines will be obtained: AC and DC Brushless Motor; Induction Motor; Synchronous Reluctance Motor; IPM Motor
Using modern simulation methods based on Matlab/Simulink tools participants will learn how to design the main control architecture scheme for torque/velocity and position including the effect of torque disturbance as well.

Obiettivi inglese: The course aims to provide a deep knowledge on the vector control of AC electric motors. At first, starting from dynamic equation, a control model on d-q axes of the following AC machines will be obtained: AC and DC Brushless Motor; Induction Motor; Synchronous Reluctance Motor; IPM Motor
Using modern simulation methods based on Matlab/Simulink tools participants will learn how to design the main control architecture scheme for torque/velocity and position including the effect of torque disturbance as well.

Modulo integrato: 93730 - ADVANCED SENSORS FOR ELECTRIC VEHICLES M		ING-INF/07	IMIS-01/B		6	60/0/0/0	No	
Ambito: 210 - Ingegneria elettrica				B				

Obiettivi: Aim of the course is to give a basic preparation, design skills, and understanding the specifications of sensors and measuring systems for automotive applications.

Obiettivi inglese: Aim of the course is to give a basic preparation, design skills, and understanding the specifications of sensors and measuring systems for automotive applications.

6713 000 000 93735 - 0 - ELECTRIC DRIVELINES M | ING-IND/32 | IIND-08/A | 6 | 60/0/0/0 | No | Voto

Ambito: 210 - Ingegneria elettrica B

Obiettivi: In this course students: 1. Learn the fundamentals of cell electrochemistry, the materials characteristics and main issues related to the manufacturing process. 2. Classify the possible cell chemistry and technology in relation to the range of application in the automotive sector. 3. Learn modelling methodology for representing the cell output characteristic and the variability of cell parameters. 4. Understanding main issues related to the pack formation by series/parallel connection of cells. 5. Learn the sizing criteria for a battery pack. 6. Understand the most innovative electrochemical storage technology. 7. Learn the fundamental principle and sizing method for energy storage systems not based on electrochemical batteries: supercapacitors and flywheel.

Obiettivi inglese: In this course students: 1. Learn the fundamentals of cell electrochemistry, the materials characteristics and main issues related to the manufacturing process. 2. Classify the possible cell chemistry and technology in relation to the range of application in the automotive sector. 3. Learn modelling methodology for representing the cell output characteristic and the variability of cell parameters. 4. Understanding main issues related to the pack formation by series/parallel connection of cells. 5. Learn the sizing criteria for a battery pack. 6. Understand the most innovative electrochemical storage technology. 7. Learn the fundamental principle and sizing method for energy storage systems not based on electrochemical batteries: supercapacitors and flywheel.

6713 000 000 93734 - 0 - ELECTRICAL POWER SYSTEMS FOR SUSTAINABLE MOBILITY M | ING-IND/33 | IIND-08/B | 6 | 60/0/0/0 | No | Voto

Ambito: 210 - Ingegneria elettrica B

Obiettivi: The course deals with electric power systems for ground transportation, with particular reference to road electric vehicles and urban mobility. Two main aspects will be covered:
- description and design of onboard power systems that enable the flexible and functional connection and coordinated operation of the vehicle energy sources, storage units and loads;
- analysis of the power and energy requests of the vehicles from the grid and integration of the feeding infrastructure in the grid. The course will provide the knowledge for the evaluation of the impact of the charging stations to the planning, operation, control, and protection of power distribution networks.
The course will provide basic notions on the concepts commonly referred to as Vehicle-to-Grid (V2G), Vehicle-to-Building (V2B) and Vehicle-to-Home (V2H). In this context, the vehicles are not seen by the network as simple loads, but they can contribute to the operation of the network or a microgrid with the provision of balancing and ancillary services.

Obiettivi inglese: The course deals with electric power systems for ground transportation, with particular reference to road electric vehicles and urban mobility. Two main aspects will be covered:
- description and design of onboard power systems that enable the flexible and functional connection and coordinated operation of the vehicle energy sources, storage units and loads;
- analysis of the power and energy requests of the vehicles from the grid and integration of the feeding infrastructure in the grid. The course will provide the knowledge for the evaluation of the impact of the charging stations to the planning, operation, control, and protection of power distribution networks.
The course will provide basic notions on the concepts commonly referred to as Vehicle-to-Grid (V2G), Vehicle-to-Building (V2B) and Vehicle-to-Home (V2H). In this context, the vehicles are not seen by the network as simple loads, but they can contribute to the operation of the network or a microgrid with the provision of balancing and ancillary services.

6713 000 000 37125 - 0 - ELECTROMAGNETIC COMPATIBILITY M | ING-INF/02 | IINF-02/A | 6 | 60/0/0/0 | No | Voto

Ambito: 1144 - Attivita' formative affini o integrative C

Obiettivi: The course will introduce the basics of electromagnetic signal propagation in an automotive environment where many different sources can influence and disturb its reliable transmission. Moreover, it will deal with the different aspects of electromagnetic compatibility of electronic circuits in complex environments. Filtering and shielding techniques for conducted and radiated disturbances will be discussed, along with conventional measurement methods and instrumentation.
The students will learn the main electromagnetic wave propagation mechanisms, how to describe and recognize unwanted conducted and radiated emission and interferences, as well as the strategies to design electromagnetically reliable and robust circuits, in accordance with national and international EMC regulation and directives.

Obiettivi inglese: The course will introduce the basics of electromagnetic signal propagation in an automotive environment where many different sources can influence and disturb its reliable transmission. Moreover, it will deal with the different aspects of electromagnetic compatibility of electronic circuits in complex environments. Filtering and shielding techniques for conducted and radiated disturbances will be discussed, along with conventional measurement methods and instrumentation.
The students will learn the main electromagnetic wave propagation mechanisms, how to describe and recognize unwanted conducted and radiated emission and interferences, as well as the strategies to design electromagnetically reliable and robust circuits, in accordance with national and international EMC regulation and directives.

6713 000 000 99705 - 0 - ENERGY STORAGE SYSTEMS AND CONTROL M I.C. | 12 | Voto

Modulo integrato: 91961 - ELECTROCHEMICAL ENERGY STORAGE AND CONVERSION M | ING-IND/32 | IIND-08/A | 6 | 60/0/0/0 | No

Ambito: 210 - Ingegneria elettrica B

Obiettivi: In this course students: 1. Learn the fundamentals of cell electrochemistry, the materials characteristics and main issues related to the manufacturing process. 2. Classify the possible cell chemistry and technology in relation to the range of application in the automotive sector. 3. Learn modelling methodology for representing the cell output characteristic and the variability of cell parameters. 4. Understanding main issues related to the pack formation by series/parallel connection of cells. 5. Learn the sizing criteria for a battery pack. 6. Understand the most innovative electrochemical storage technology. 7. Learn the fundamental principle and sizing method for energy storage systems not based on electrochemical batteries: supercapacitors and flywheel.

Obiettivi inglese: In this course students: 1. Learn the fundamentals of cell electrochemistry, the materials characteristics and main issues related to the manufacturing process. 2. Classify the possible cell chemistry and technology in relation to the range of application in the automotive sector. 3. Learn modelling methodology for representing the cell output characteristic and the variability of cell parameters. 4. Understanding main issues related to the pack formation by series/parallel connection of cells. 5. Learn the sizing criteria for a battery pack. 6. Understand the most innovative electrochemical storage technology. 7. Learn the fundamental principle and sizing method for energy storage systems not based on electrochemical batteries: supercapacitors and flywheel.

Modulo integrato: 35166 - DIAGNOSIS AND CONTROL M | ING-INF/04 | IINF-04/A | 6 | 60/0/0/0 | No

Ambito: 1144 - Attivita' formative affini o integrative C

Obiettivi: L'insegnamento mira a fornire una sistematica visione delle principali metodologie e norme tecniche che devono essere utilizzate per affrontare in modo razionale e consistente le problematiche legate ai guasti e ai malfunzionamenti dei moderni sistemi ingegneristici.
Gli argomenti del corso includono sia metodologie di diagnosi dei guasti, sia strumenti e norme legate alla functional safety e che regolano la progettazione di sistemi safety-critical.
Al termine del corso,
- lo studente conosce gli strumenti e le procedure fondamentali per affrontare la failure/hazard analysis, la occurrence/risk assessment e la occurrence/risk reduction;
- lo studente conosce alcuni importanti strumenti e metodi per la progettazione di algoritmi di fault detection and isolation legati alla teoria dei sistemi e dei controlli automatici.

Obiettivi inglese: The course aims to give a systematic overview of the primary methodologies and technical norms that have to be used to rationally overcome issues related to faults and malfunctioning affecting modern engineering systems. The course topics include fault diagnosis methodologies as well as functional safety tools and standards that regulate the design of safety-critical systems.
At the end of the course,
- students will know fundamental tools and procedures to deal with failure/hazard analysis, occurrence/risk assessment, and occurrence/risk reduction;
- students will know some relevant tools and methods to design fault detection and isolation algorithms linked to system and control theory.

6713 000 000 93736 - 0 - POWER ELECTRONIC CONVERTERS M | ING-IND/31 | IIET-01/A | 6 | 60/0/0/0 | No | Voto

Ambito: 210 - Ingegneria elettrica B

Obiettivi: The course initially provides supplements of linear and non-linear electric circuits with special emphasis towards power electronic circuits for electric vehicles. The digital controllers for power electronic converters are also examined, such as DSP boards, digital microcontrollers, FPGA systems. The main power electronic switches employed in the electric vehicles are introduced, such as power diodes, Mosfets, IGBTs, SiC and emerging power components. The considered converter configurations, and the corresponding modulation strategies, are: passive and active single-phase and three-phase rectifiers (vehicle power interface with the electric grid), three-phase inverters (vehicle motor drive), dc/dc choppers configurations (on board and off board battery chargers). Battery charging modes for electric vehicles are introduced and duscussed. The features Grid-to- Vehicle (G2V), Vehicle-to-Grid (V2G), Vehicle-to-Vehicle (V2V), Vehicle-to-Load (V2L), and Vehicle-for-Grid (V4G) are considered for the regulation of the power converters, with reference to both off board dc fast charging stations and onboard ac chargers.

Obiettivi inglese: The course initially provides supplements of linear and non-linear electric circuits with special emphasis towards power electronic circuits for electric vehicles. The digital controllers for power electronic converters are also examined, such as DSP boards, digital microcontrollers, FPGA systems. The main power electronic switches employed in the electric vehicles are introduced, such as power diodes, Mosfets, IGBTs, SiC and emerging power components. The considered converter configurations, and the corresponding modulation strategies, are: passive and active single-phase and three-phase rectifiers (vehicle power interface with the electric grid), three-phase inverters (vehicle motor drive), dc/dc choppers configurations (on board and off board battery chargers). Battery charging modes for electric vehicles are introduced and duscussed. The features Grid-to- Vehicle (G2V), Vehicle-to-Grid (V2G), Vehicle-to-Vehicle (V2V), Vehicle-to-Load (V2L), and Vehicle-for-Grid (V4G) are considered for the regulation of the power converters, with reference to both off board dc fast charging stations and onboard ac chargers.

Gruppo: 2) Elective courses

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

Cfu min: 12 Cfu max: 12
Note: Choose 12 credits among the following courses:

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

6713 000 000 35167 - 0 - COMMUNICATION SYSTEMS: THEORY AND MEASUREMENT M	ING-INF/03	IINF-03/A	6	60/0/0/0	No	Voto

Ambito: 1144 - Attivita' formative affini o integrative C

Obiettivi: At the end of the course the students acquire the knowledge and the ability to cope with modulation/demodulation techniques, signal processing and receiver architectures, measurement of spectra, signals and filter design.

Obiettivi inglese: At the end of the course the students acquire the knowledge and the ability to cope with modulation/demodulation techniques, signal processing and receiver architectures, measurement of spectra, signals and filter design.

6713 000 000 93737 - 0 - DYNAMICS AND COMPLIANT CONTROL OF ELECTRIC VEHICLES M	ING-IND/13	IIND-02/A	6	60/0/0/0	No	Voto

Ambito: 1144 - Attivita' formative affini o integrative C

Obiettivi: The course deals with dynamics and control of electric vehicles and with the compliant implementation of control policies on the programmable electronics systems that supervise the operation of the vehicle. The students will learn to describe a vehicle as a 3-D dynamic system, design optimal control strategies, and implement such strategies on the programmable electronics systems that supervise the operation of the vehicle, with focus on compliance with safety and reliability standards.

Obiettivi inglese: The course deals with dynamics and control of electric vehicles and with the compliant implementation of control policies on the programmable electronics systems that supervise the operation of the vehicle.
The students will learn to describe a vehicle as a 3-D dynamic system, design optimal control strategies, and implement such strategies on the programmable electronics systems that supervise the operation of the vehicle, with focus on compliance with safety and reliability standards.

6713 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: 1144 - Attivita' formative affini o integrative C

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.

6713 000 000 B2362 - 0 - WIRELESS POWER TRANSFER FOR SUSTAINABLE MOBILITY M	ING-INF/02	IINF-02/A	6	60/0/0/0	No	Voto

Ambito: 1144 - Attivita' formative affini o integrative C

Obiettivi: L'obiettivo del corso è fornire gli strumenti analitici, numerici e le competenze necessarie per il progetto d'interi sistemi di trasmissione di potenza wireless a dispositivi sia statici che in movimento, per diversi valori di potenza e a diverse frequenze di lavoro. Il corso intende anche fornire le soluzioni progettuali idonee a garantire la compatibilità di tali sistemi in ambienti umanizzati.

Si studiano le tecniche analitiche e numeriche per l'analisi ed il progetto di sistemi per la trasmissione wireless di potenza in campo vicino, verso dispositivi statici ed in movimento. Si affronta il progetto di diverse architetture, basate sia su accoppimento induttivo che capacitivo, a elementi singoli e multipli. Vengono inoltre analizzati e progettati i principali componenti circuitali per la trasmissione e la ricezione della potenza e le relative funzioni di merito. Vengono studiate le principali non linearità responsabili della conversione dell'energia, da RF a DC e viceversa, e gli strumenti CAD per il progetto dell'intero sistema. Sono previste attività sperimentali di laboratorio in cui verranno progettati e caratterizzati semplici sistemi rappresentativi per la trasmissione di potenza sia statica che dinamica e le loro principali caratteristiche.

Obiettivi inglese: The objective of the course is to provide analytical, numerical tools and the necessary skills for the design of entire wireless power transmission systems to both static and “on-the-move” devices, for different power values and at different working frequencies. The course intends to provide the design solutions to ensure the compatibility of such systems in humanized environments.

The analytical and numerical techniques for the analysis and design of near-field wireless power transmission systems towards static and moving devices are developed. design of Different architectures will be developed, based on both inductive and capacitive coupling, with single and multiple elements coils/capacitive plates. The main circuit components for the transmission and reception of power and the related figures of merit are also addressed. The main non-linearities responsible for the energy conversion, from RF to DC and vice versa, and the CAD tools for the design of the entire system are studied. Experimental laboratory activities are foreseen in which simple representative systems, for both static and dynamic power transmission operations and their main characteristics, will be designed and characterized.

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.
6713 000 000 93739 - 0 - AUTOMOTIVE POWER CIRCUITS AND ELECTRIC MOTOR DESIGN M I.C.					12			Voto
Modulo integrato: 93740 - AUTOMOTIVE POWER ELECTRONIC CIRCUITS DESIGN M		ING-IND/32	IIND-08/A		6	60/0/0/0	No	
Ambito: 210 - Ingegneria elettrica				B				
Obiettivi: Students learn the methodology and the use of design tools for developing and testing the main power electronic converters used in the automotive sector. Students learn the modelling techniques for FEM electromagnetic analysis of high frequency magnetic components and for modelling of mixed signal circuits. Students receive a complete technology review for power circuitry, passive components, active devices, cooling technologies, mixed signal circuits, sensors, control devices and control circuits. Students focus on the principle of operation and design of automotive related power converter topologies: PFC and Phase Shift Full Bridge for the On Board Charger (OBC), dual-level and multilevel three-phase inverter for the traction drive, flyback and LLC circuit for the on board auxiliary converters.								
Obiettivi inglese: Students learn the methodology and the use of design tools for developing and testing the main power electronic converters used in the automotive sector. Students learn the modelling techniques for FEM electromagnetic analysis of high frequency magnetic components and for modelling of mixed signal circuits. Students receive a complete technology review for power circuitry, passive components, active devices, cooling technologies, mixed signal circuits, sensors, control devices and control circuits. Students focus on the principle of operation and design of automotive related power converter topologies: PFC and Phase Shift Full Bridge for the On Board Charger (OBC), dual-level and multilevel three-phase inverter for the traction drive, flyback and LLC circuit for the on board auxiliary converters.								
Modulo integrato: 93741 - ELECTRIC MOTOR DESIGN M		ING-IND/32	IIND-08/A		6	60/0/0/0	No	
Ambito: 210 - Ingegneria elettrica				B				
Obiettivi: The aims of the Course are to train the students to the specific knowledge regarding the traditional methodologies for the analaysis and the design of the electrical machines. Furthermore, the appropriate use of simulation software and thermal and electromagnetic field analysis will be presented and discussed. Special attention is paid to the design of brushless machines, with reference to different topology employed in the automotive sector for both traction in BEV and in HEV and for auxiliary drives (EPS,HVAC, fans).								
Obiettivi inglese: The aims of the Course are to train the students to the specific knowledge regarding the traditional methodologies for the analaysis and the design of the electrical machines. Furthermore, the appropriate use of simulation software and thermal and electromagnetic field analysis will be presented and discussed. Special attention is paid to the design of brushless machines, with reference to different topology employed in the automotive sector for both traction in BEV and in HEV and for auxiliary drives (EPS,HVAC, fans).								
6713 000 000 B8299 - 0 - LABORATORY OF ELECTRICAL INSULATION SYSTEM M					3	0/0/30/0	No	Giudizio
Ambito: 1147 - Altre conoscenze utili per l'inserimento nel mondo del lavoro				F				
Obiettivi: After completing the course, the student knows the specific features of different materials and insulation systems. For each equipment used in transport electrification, the student understands the choices leading to the selection of a specific insulation system on the basis of the equipment stress and utilization profiles. The student is thus autonomous in developing electrical insulation systems for novel applications. The student is also able to plan and execute tests to demonstrate the quality of insulation systems. The student will also be able to test and diagnose complete equipment. ha il menu contestuale.								
Obiettivi inglese: After completing the course, the student knows the specific features of different materials and insulation systems. For each equipment used in transport electrification, the student understands the choices leading to the selection of a specific insulation system on the basis of the equipment stress and utilization profiles. The student is thus autonomous in developing electrical insulation systems for novel applications. The student is also able to plan and execute tests to demonstrate the quality of insulation systems. The student will also be able to test and diagnose complete equipment. ha il menu contestuale.								

6713 000 000 93742 - 0 - VEHICLE DESIGN AND CONNECTIVITY M I.C. 6 Voto

Modulo integrato: 93743 - VEHICLE CONCEPTUAL DESIGN M ING-IND/15 IIND-03/B 3 30/0/0/0 No

Ambito: 1144 - Attivita' formative affini o integrative C

Obiettivi: Lectures aim at technically describing the overall layout, architecture and main functional systems of an Electric Vehicle (EV). The goal is the transmission of an integrated approach to the comprehension and design synthesis of EVs. Main contents are: definition of the architecture of a vehicle; Design activity flow: task clarification, conceptual design, embodiment design, detail design; historical evolution; graphic representation systems; body work (Body in White; Body Side; Fenders; Roof assembly; Front frame; Rear frame; compartment floor; closed bodies; spider, coupe and cabrio); body components (outer body components, weather strips, glass and mirrors, movable parts, windshield wiper, vehicle lighting and signalling); body interiors (restraint systems - safety belts; restraint system -- air-bag; dashboard cockpit - dashboard - console; interior trims; seats; air conditioning system).

Obiettivi inglese: Lectures aim at technically describing the overall layout, architecture and main functional systems of an Electric Vehicle (EV). The goal is the transmission of an integrated approach to the comprehension and design synthesis of EVs. Main contents are: definition of the architecture of a vehicle; Design activity flow: task clarification, conceptual design, embodiment design, detail design; historical evolution; graphic representation systems; body work (Body in White; Body Side; Fenders; Roof assembly; Front frame; Rear frame; compartment floor; closed bodies; spider, coupe and cabrio); body components (outer body components, weather strips, glass and mirrors, movable parts, windshield wiper, vehicle lighting and signalling); body interiors (restraint systems - safety belts; restraint system -- air-bag; dashboard cockpit - dashboard - console; interior trims; seats; air conditioning system).

Modulo integrato: 85740 - AUTOMOTIVE CONNECTIVITY M ING-IND/15 IIND-03/B 3 30/0/0/0 No

Ambito: 1144 - Attivita' formative affini o integrative C

Obiettivi: The aim of the module is to provide the students with the fundamental knowledge to recognize and to utilize the main on board networks and protocols interacting with the driveline and the foundamental techniques for vehicle to internet interconnection. Students learn the principle of operation and use vehicular networking and protocols: 1) CAN
vehicular network (characteristic, application, implementation); 2) UDS - Universal Diagnostic Service characteristic and
implementation; 3) XCP – Universal calibration protocol. Students understand the basic features and application of the Vehicle to infrastructure networking: 1) Vehicle to Internet communication services (TCP/IP, etc…): 2) Data compression and data transmission. 3) DoIP: Diagnosis and service over the internet. 4) Edge and cloud computing for predictive maintenance. 5) Electric vehicle Fleet management. 6) Remote Battery Management System. Improvement of battery safety control and second life battery use.

Obiettivi inglese: The aim of the module is to provide the students with the fundamental knowledge to recognize and to utilize the main on board networks and protocols interacting with the driveline and the foundamental techniques for vehicle to internet interconnection. Students learn the principle of operation and use vehicular networking and protocols: 1) CAN
vehicular network (characteristic, application, implementation); 2) UDS - Universal Diagnostic Service characteristic and
implementation; 3) XCP – Universal calibration protocol. Students understand the basic features and application of the Vehicle to infrastructure networking: 1) Vehicle to Internet communication services (TCP/IP, etc…): 2) Data compression and data transmission. 3) DoIP: Diagnosis and service over the internet. 4) Edge and cloud computing for predictive maintenance. 5) Electric vehicle Fleet management. 6) Remote Battery Management System. Improvement of battery safety control and second life battery use.

6713 000 000 93733 - 0 - VEHICLE ENERGETICS AND HVAC SYSTEMS M ING-IND/10 IIND-07/A 6 60/0/0/0 No Voto

Ambito: 1144 - Attivita' formative affini o integrative C

Obiettivi: The main aspects of vehicle climate control systems for automotive engineering are explored, with a special focus to electric vehicle applications. A thorough up-to-date knowledge of current A/C systems, with the common used refrigerants and the new possible replacement systems, the electronic and electrical controls are enlightened. Recent approaches to optimise the interaction between cabin vehicle climate control system and electronic and electric devices cooling system are shown.

Obiettivi inglese: The main aspects of vehicle climate control systems for automotive engineering are explored, with a special focus to electric vehicle applications. A thorough up-to-date knowledge of current A/C systems, with the common used refrigerants and the new possible replacement systems, the electronic and electrical controls are enlightened. Recent approaches to optimise the interaction between cabin vehicle climate control system and electronic and electric devices cooling system are shown.

Gruppo: 2) Final examination

TAF: Ambito:

Cfu min: 24 Cfu max: 24

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 0-24

6713 000 000 60750 - 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.

2.2) Group B 0-24

6713 000 000 86301 - 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.

6713 000 000 84551 - 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.

6713 000 000 86296 - 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.

6713 000 000 84548 - 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: 3) Courses freely chosen by the student

TAF: D Ambito: 1008 - A scelta dello studente

Cfu min: 9 Cfu max: 9

Note: Choose at least 9 credits among the courses offered in the university of Bologna, or the Universities of Modena and Reggio Emilia, Parma and Ferrara. The Programme board suggests to attend to the following courses:

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

6713 000 000 99549 - 0 - APPLIED SUPERCONDUCTIVITY FOR ENERGY TRANSITION M	ING-IND/31	IIET-01/A	6	60/0/0/0	No	Voto

Ambito: 1008 - A scelta dello studente D

Obiettivi: Il corso si propone di illustrare i concetti fondamentali relativi alle applicazioni industriali dei materiali superconduttori ai sistemi magnetici, e ai sistemi su larga scala per la transizione energetica nei trasporti e nella rete elettrica. Si introducono i concetti e le proprietà fondamentali che caratterizzano i materiali superconduttori ad alta e bassa temperatura critica. Si trattano i principali problemi tecnologici relativi alla realizzazione di dispositivi superconduttivi, includendo aspetti elettromagnetici, termici (criogenia) e meccanici. Si introducono i principi di fun-zionamento e i criteri progettuali delle principali applicazioni industriali della superconduttività, con particolare riferimento alla tecnologia dei magneti (fusione termonucleare controllata, acceleratori, sistemi per la risonanza magnetica, sistemi per la levitazione magnetica) e ai sistemi elet-trici per l'energia (cavi, macchine elettriche).

Obiettivi inglese: This course aims to illustrate the fundamental concepts related to the analysis and synthesis of magnetic systems and large-scale applications of superconductivity for the energy transition. The electrical and magnetic properties that characterize the behavior of low and high critical temperature superconducting materials are introduced. The most relevant technological issues concerning electromagnetic, thermal (cryogenics) and mechanical aspects of superconducting devices are treated in the course. The working principles and design criteria of the main large-scale applications of superconductivity are described, with particular reference to magnet technology (controlled thermonuclear fusion machines, accelerators, magnetic resonance imaging systems, mag-netic levitation) and to the power systems (cables, electrical machines).

6713 000 000 35167 - 0 - COMMUNICATION SYSTEMS: THEORY AND MEASUREMENT M	ING-INF/03	IINF-03/A	6	60/0/0/0	No	Voto

Ambito: 1144 - Attivita' formative affini o integrative C

Obiettivi: At the end of the course the students acquire the knowledge and the ability to cope with modulation/demodulation techniques, signal processing and receiver architectures, measurement of spectra, signals and filter design.

Obiettivi inglese: At the end of the course the students acquire the knowledge and the ability to cope with modulation/demodulation techniques, signal processing and receiver architectures, measurement of spectra, signals and filter design.

6713 000 000 87231 - 0 - INSTRUMENTATION FOR ELECTRICAL ENGINEERING M	ING-INF/07	IMIS-01/B	6	60/0/0/0	No	Voto

Ambito: 1008 - A scelta dello studente D

Obiettivi: Il Corso intende fornire agli studenti della Laurea Magistrale in Electrical Engineering le conoscenze inerenti le tipologie di strumenti (sia strumenti da banco che virtuali) e sistemi di misura utilizzati per le misure, la diagnostica e la caratterizzazione di componenti e sistemi nel campo dell'ingegneria elettrica. Gli argomenti trattati includono il loro principio di funzionamento, l'architettura interna, con riferimento ai circuiti di condizionamento dei segnali in ingresso, gli accessori (sensori, sonde, ecc.), i principali protocolli di comunicazione utilizzati per le trasmissioni delle misure da remoto, i criteri per una corretta scelta dello strumento più adatto in base alla applicazione, nonché una approfondita parte relativa al loro corretto utilizzo, con particolare riferimento alla valutazione della incertezza di misura.

Obiettivi inglese: The course aims to provide students of the Master's Degree in Electrical Engineering with the knowledge inherent the types of instruments (both stand-alone and virtual instruments) and measurement systems used for the measurements, diagnostics and characterization of components and systems in the electric engineering sector. The topics covered include the instrumentation operating principle, the internal architecture (with reference to the input signals conditioning circuits), the sensors and probes, the main communication protocols used for the transmission of remote measurements, the criteria for a correct choice of the most suitable instrument depending on the application, as well as an in-depth part relating to their correct use, with particular reference to the evaluation of measurement uncertainty.

6713 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.

6713 000 000 78858 - 0 - LABORATORY OF BUSINESS PLAN M			3	0/0/30/0	No	Giudizio

Ambito: F

Obiettivi: The overall purpose of the course is for students to acquire knowledge and abilities within the area of entrepreneurship, with particular focus on idea feasibility analysis and business planning for new, innovative, technology based ventures. After the course, students are able to account for and compare different theories that describe what it takes to start up and organize innovative ventures, to account for the information and the analyses needed to do a feasibility analysis and write a draft business plan for an innovative venture and have the ability to collect and analyze relevant information for that purpose. They are also able to communicate a feasibility analysis/business plan orally and in writing.

Obiettivi inglese: The overall purpose of the course is for students to acquire knowledge and abilities within the area of entrepreneurship, with particular focus on idea feasibility analysis and business planning for new, innovative, technology based ventures. After the course, students are able to account for and compare different theories that describe what it takes to start up and organize innovative ventures, to account for the information and the analyses needed to do a feasibility analysis and write a draft business plan for an innovative venture and have the ability to collect and analyze relevant information for that purpose. They are also able to communicate a feasibility analysis/business plan orally and in writing.

6713 000 000 92993 - 0 - MODELING AND SIMULATION OF MECHATRONIC SYSTEMS M	ING-INF/04	IINF-04/A	9	90/0/0/0	No	Voto

Ambito: 1008 - A scelta dello studente D

Obiettivi: Al termine del corso lo studente conosce i principi e le metodologie principali per la progettazione integrata di un sistema meccatronico, partendo dalla modellazione matematica e simulazione numerica, per giungere fino all'implementazione della legge di controllo, che può essere validata sul modello simulato. Questi principi generali sono esaminati in dettaglio e con un taglio orientato alla progettazione del sistema di controllo, anche attraverso una serie di attività progettuali che gli studenti dovranno portare a termine sotto la supervisione del docente. Attività di laboratorio su set-up "reali" sono una parte caratterizzante del corso stesso, ed hanno come scopo quello di fornire agli studenti conoscenze di base per lo sviluppo e l'implementazione di algoritmi di controllo su architetture real-time.

Obiettivi inglese: The course provides the basics for the analysis of modern power systems/smart grids in steady state and transient/dynamic conditions. At the end of the course, students
- know the main technical aspects of electric power transmission networks;
- can carry out power flows calculations, fault analysis, assessment of angular, voltage, and frequency stability;
- can analyze the electromagnetic transients in the lines.

6713 000 000 93038 - 0 - OPTICAL TECHNOLOGIES FOR ELECTRICAL ENGINEERING M	ING-INF/02	IINF-02/A	6	60/0/0/0	No	Voto

Ambito: 1008 - A scelta dello studente 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.

6713 000 000 85752 - 0 - PRODUCT SAFETY, PRODUCT LIABILITY AND AUTOMOTIVE M	IUS/01	GIUR-01/A	6	60/0/0/0	No	Voto

Ambito: 1008 - A scelta dello studente D

Obiettivi: The main purpose of the course is to provide students with a thorough knowledge of the core concepts of tort law in the automotive industry issues not only from a national perspective but also from the perspective of the harmonization of European Union Law and the US legal system. The course aims at providing the student with a general knowledge of basic principles and concepts of European Union and US tort law and consumer protection law focused on the automotive industry issues. It also focuses on Corporate social responsibility and environmental and technological innovation issues that the automotive industry faces. Using the method of the economic analysis of law, the current UE and US legal system will be evaluated in the light of a pragmatic proposal to check that the basic liability law can still function properly in the light of rapid changes to some of the products that it covers. The attention will focuses on the new issues arising from highly automated vehicles. In this prospective it will be investigated the role of the precautionary principle governing the UE consumer protection law, and the risks development doctrine which can be seen as a limit to the manufacturer liability. The automotive litigation prospective also leads to focus the attention on class action and punitive damages which play a crucial role in the American legal system and are not still implemented in UE legal system. At the end of the course the student is expected to become familiar with the legal notions of producer, consumer, tort law, damage, product liability law and product safety law governing the automotive industry, in order to observe the problem of the automotive litigation in a globalized prospective. At the end of the course the student is expected to become familiar with the legal notions of producer, consumer, tort law, damage, product liability law and product safety law governing the automotive industry, in order to observe the problem of the automotive litigation in a globalized prospective.

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Ambito: 1008 - A scelta dello studente D

Obiettivi: The course will first address the problem of fault modeling, with reference to the automotive environment, to then study testing, design for testability and hardware in the loop approaches.
Then, onboard monitoring and diagnosis will be addressed, to finally study fault tolerant techniques for reliable systems' design. The course will include laboratory experiences, and possible seminars given by experts in the field from the industrial world.

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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.