DIDACTIC REGULATIONS OF THE DEGREE PROGRAM

MECHANICAL ENGINEERING FOR ENERGY AND ENVIRONMENT

CLASS LM-33

School: Polytechnical and Basic Sciences

Department: Industrial Engineering

Regulations in force since the academic year 2025 -2026

ACRONYMS

CCD	[Commissione di Coordinamento Didattico]	Didactic Coordination Commission
CdS	[Corso/i di Studio]	Degree Program
CFU	[Crediti Formativi Universitari = 1 ECTS]	University training credits
CPDS	[Commissione Paritetica Docenti-Studenti]	Joint Teachers-Students Committee
OFA	[Obblighi Formativi Aggiuntivi]	Additional Training Obligations
SUA-CdS	[Scheda Unica Annuale del Corso di Studio]	Annual single form of the Degree Program
RDA	[Regolamento Didattico di Ateneo]	University Didactic Regulations

INDEX

Art. 1
Object

1. These Didactic Regulations rule the organisational aspects of the CdS in Mechanical Engineering for Energy and Environment (class LM-33). The CdS in Mechanical Engineering for Energy and Environment is hinged in the Department of Industrial Engineering. It is held in Italian and English languages and it is delivered in a conventional modality.
2. The CdS is governed by the Didactic Coordination Commission (CCD), complying with Art. 4 of the RDA.
3. The Didactic Regulations are issued in compliance with the relevant legislation in force, the Statute of the University of Naples Federico II, and the RDA.

Art. 2
Training objectives

The IMEA Degree program aims at training graduates capable of dealing with recurring problems in classical mechanical engineering. At the same time, the program focuses on more specific aspects in the thermo-mechanical, technical, and technological fields, with reference to the rational use of energy sources and environmental sustainability. The CdS therefore provides high-level skills and knowledge that are useful especially in a multidisciplinary context, encouraging teamwork, according to the current approach in the industrial context.

The structure of the IMEA program allows the graduates to satisfy the needs related to a wide range of roles which the industrial engineer normally plays in companies producing goods and/or services, engineering companies, engineering design studios, etc., with reference to issues of conversion, accumulation, distribution and final use of energy. In general, the IMEA graduates are involved in all issues related to the management, optimization and reduction of the environmental impact of energy systems and production processes. IMEA graduates typically carry out a set of professional roles which include:

- optimal design, realization and management, also from an environmental point of view, of systems of varying complexity for the conversion, distribution, storage and end use of energy, with reference to both conventional and advanced technologies, and in particular to those of interest for the ongoing energy and ecological transition;
- design and operation of driving and driven machines, or systems that carry out thermo-fluid dynamic processes for energy applications, as well as high-efficiency propulsion systems for sustainable ground mobility;
- design and operation of industrial plants and processes, in the various sectors of energy conversion in compliance with environmental laws;
- analysis and certification of the energy and environment compatibility of industrial plants and environmental revamping interventions;
- energy simulation of plant-users systems for the purposes of performance characterization, definition of operational and control maps;
- thermodynamic and economic optimization of complex energy systems, such as those based on distributed poly-generation from renewable sources or equivalent, with an outlook to the energy transition.

In all the above listed cases, the IMEA graduates will be able to deal with advanced analysis and design problems related to fluid machinery and energy conversion systems and therefore will play a role of fundamental importance in supporting the design and operation of complex systems, also providing the technical support necessary for the definition and execution of experimental activities. They will also be able to verify the proper compliance with technical regulations in the construction

and operation of the systems, as well as to propose improvements, with particular reference to those related to the energy and environmental sectors.
The educational program also trains graduates offering the ability to communicate correctly in the technical-scientific field and to effectively use the scientific literature. Finally, the learning ability gained during the degree program enables IMEA graduates to acquire new knowledge and methodologies during the development of their professional activity, or to profitably deal with advanced post-degree courses (1st and 2nd level Masters, Ph.D).

The study plan is organized in multiple curricula, one of which is offered in English. With reference to the characterizing topics, each plan includes both mandatory training activities, differentiated according to the study plan, and trainings with guided choice, taken from a pool of subjects partially common to different plans. This allows to customize the study plan on more analytical or modelling/experimental aspects. A strong interdisciplinarity is introduced thanks to the large room dedicated to related or complementary trainings (max 21 CFU) and trainings at the student's choice (max 15 CFU).

The articulation in multiple paths allows to differentiate and/or appropriately intersect the learning areas functional to train the professional figures foreseen in Framework A2.a. In particular:

- A first professional figure is trained, oriented to the design of components, machines and systems for the production of energy of mechanical, thermal or refrigeration type, originating from traditional or renewable sources. The training is carried out by balancing contents related both to the learning area in the "energy and environmental control field" and to that relating to "Fluid machines and energy systems".
- The training of the second professional figure is more oriented towards the efficiency and thermo-economic optimization of complex energy systems, including those based on distributed polygeneration. The formation path focuses mainly, but not exclusively, on the learning area in the "energy and environmental control sector".
- The training of the third professional figure focuses on the design, analysis and control of a modern land propulsion system (traditional or hybrid, powered by conventional or innovative fuels). This formation path focuses on contents mainly, but not exclusively, related to "Fluid machines and energy systems".
- A fourth more generalist professional profile is also provided, partially introducing elements common to the previous figures. The formation path includes therefore learning topics related to the "energy and environmental control" area and to the "Fluid machines and energy systems" area, as well.

With the aim of promoting the training of engineering professionals with a marked interdisciplinary character, students enrolled in the Course of Studies are offered the opportunity to participate, in partial overlap with the Master's degree studies, in Minor courses, active in the University, governed by specific regulations and associated to the present and to other CdS. Pursuant to Art. 18, c. 2 of the University Teaching Regulations, admission to the Minor path gives rise to a career distinct from that of the Study Course in which the student is enrolled. The activities foreseen in the Minor path can be recognized within the career of students enrolled in the Study Course, consistently with the Teaching System and Didactic Regulations. In any case at least 6 CFU completed in the Minor courses must be reserved for extra-curricular activities in addition to the CFU of the statutory plan for obtaining the qualification (pursuant to Art. 18, c. 1, of the University Teaching Regulations).

Each study plan includes further training activities, an intra-moenia or extra-moenia internship, and a final exam. The set of these activities has the objective of giving the graduate the ability to communicate correctly (also in English) in the technical-scientific field, to use the relevant scientific literature profitably and to acquire new knowledge and methodologies (including IT) during the development of his/her own professional career.

Art. 3
Professional profile and work opportunities

Designer of energy systems and components for the production of energy from traditional and renewable sources.

Functions in a work context:
This professional profile enjoys specific skills for the design of components and systems producing mechanical, thermal and refrigeration energy. This job title can evaluate the performance of machines and systems for the split or combined production of mechanical and thermal energy. This role includes the design and optimization of systems and components for heat exchange, for winter and summer air conditioning and of systems for the combined polygeneration of different forms of energy.
Skills associated with the functions:
He/she knows the most suitable fluids for heat exchange.
He/she knows and is able to use and integrate traditional and renewable energy sources.
He/she uses thermo-fluid-dynamic modeling tools and mathematical optimization methods as applied to energy systems.
He/she knows the criteria for evaluating, choosing and coupling electrical systems designed for energy conversion applications.
Employment opportunities:
- manufacturing, mechanical, chemical, petrochemical and process industries;
- public/private companies operating in the sector of technologies for the production, accumulation and transport of energy;
- industries producing machines, heat exchangers, refrigeration, air conditioning and steam production systems;
- professional engineering office.

Expert in advanced technologies for the rational use of energy and the quality of the built environment.

Functions in a work context:
This professional profile can analyze and plan interventions for the rational use of traditional and renewable energy sources, also from a technical-economic point of view. This job title designs thermo-technical systems for buildings and realizes energy-efficient building envelopes. This role includes the certification of the thermal, hygrometric and acoustic performance of industrial and civil environments and requires the critical evaluation of data on the energy consumption of industrial sites and civil buildings. The design and implement of control strategies for gas turbine, steam, combined cycle and cogeneration units, are included, too.
Skills associated with the functions:
He/she knows the electricity and thermal tariff dynamics.
He/she uses analysis, modeling and optimization tools in the field of micro-climatics and acoustics of confined environments.
He/she knows the theory of measurement and the main sensors for the quantification of thermo-fluid-dynamic quantities.

He/she has technical-economic management skills of industrial and civil plants.

Employment opportunities:

- Public companies and institutions operating in the sectors of energy efficiency, renewable sources, environmental services;
- Companies, engineering companies, design office that offer technical, commercial and financial services to promote, design and build thermotechnical systems, energy conversion systems powered by renewable sources, systems and interventions for energy efficiency in industry and in buildings and for the energy transition, in general;
- ESCOs (energy services companies) and, in general, companies that provide goods and services in the energy field;
- Expert in Energy Management (EGE) at institutions and companies;
- Energy Services Manager (GSE).

Expert in the design of fluid machines and in the analysis, calibration and control of propulsion systems.

Functions in a work context:

This professional profile is able to design from a fluid dynamic point of view the machines and components that make up energy production systems and propulsion systems, including hybrid ones, for small and large power mobility.

This job title is able to optimize the performance of machines and propulsion systems and implements design choices aimed at reducing harmful and carbon dioxide emissions.

Skills associated with the functions:

He/she knows the problems of coupling the machines.

He/she knows the approval regulations for propulsion systems.

He/she uses modeling methods and experimental techniques for the characterization of machines.

He/she knows the problems of calibration and control of internal combustion engines and more generally of complex high energy efficiency propulsion systems

Employment opportunities:

- Engine companies and suppliers of components for propulsion systems;
- industries that produce components and energy conversion systems (engines, turbochargers);
- suppliers of components for hydraulic and pneumatic systems;
- companies in the automotive and noise control sectors.

Art. 4
Admission requirements and knowledge required for access to the Degree Program[1]

To enroll in a Master's Degree course, it is necessary to have a three-year university degree or diploma, or another qualification acquired abroad and recognized as suitable. Furthermore, the possession of specific curricular requirements and the mandatory verification of the adequacy of the student's personal preparation are required. The latter includes the possession of adequate language skills and is assessed using criteria defined in the Didactic Regulations of the Degree program.

For enrollment in the LM-IMEA the curricular requirements is a degree in the class of degrees in Industrial Engineering (class 10 of Ministerial Decree 509/99 and L-9 of Ministerial Decree 270/04) or equivalent qualification, or, **alternatively**, to have obtained at least **90 CFU** in specific scientific-disciplinary sectors, classified as follows:

[1] Artt. 7, 13, 14 of the University Didactic Regulations.

At least **40 CFU** from the academic disciplines:
MATH-02/A (ex MAT/02) - Algebra
MATH-02/B (ex MAT/03) - Geometry
MATH-03/A (ex MAT/05) - Mathematical Analysis
MATH-03/B (ex MAT/06) - Probability and Statistics
MATH-04/A (ex MAT/07) - Mathematical Physics
MATH-05/A (ex MAT/08) - Numerical Analysis
MATH-06/A (ex MAT/09) - Operations Research
STAT-01/A (ex SECS-S/01) - Statistics
STAT-01/B (ex SECS-S/02) - Statistics for Experimental and Technological Research
IINF-05/A (ex ING-INF/05) - Information Processing Systems
PHYS-01/A (ex FIS/01/04) - Experimental Physics of Fundamental Interactions and Applications
PHYS-03/A (ex FIS/01/03) - Experimental Physics of Matter and Applications
PHYS-04/A (ex FIS/02/03) - Theoretical Physics of Matter, Models, Mathematical Methods and Applications
CHEM-03/A (ex CHIM/03) - General and Inorganic Chemistry
CHEM-04/A (ex CHIM/04) - Industrial Chemistry
CHEM-06/A (ex CHIM/07) - Principles of Chemistry for Applied Technologies

At least **50 CFU** from the academic disciplines:
CEAR-06/A (ex ICAR/08) - Structural Mechanics
IIND-01/F (ex ING-IND/06) - Fluid Dynamics
IIND-01/G (ex ING-IND/07) - Aerospace Propulsion
IIND-06/A (ex ING-IND/08) - Fluid Machinery
IIND-06/B (ex ING-IND/09) - Energy Systems and Power Generation
IIND-07/A (ex ING-IND/10) - Thermal Engineering and Industrial Energy Systems
IIND-07/B (ex ING-IND/11) - Building Physics and Building Energy Systems
IMIS-01/A (ex ING-IND/12) - Mechanical and Thermal Measurements
IIND-02/A (ex ING-IND/13) - Applied Mechanics
IIND-03/A (ex ING-IND/14) - Mechanical Design and Machine Construction
IIND-03/B (ex ING-IND/15) - Design Methods for Industrial Engineering
IIND-04/A (ex ING-IND/16) - Manufacturing Technology and Systems
IIND-05/A (ex ING-IND/17) - Industrial Mechanical Systems Engineering
IMAT-01/A (ex ING-IND/22) - Materials Science and Technology
ICHI-01/B (ex ING-IND/24) - Fundamentals of Chemical Engineering
ICHI-02/A (ex ING-IND/25) - Chemical Plants
ICHI-01/C (ex ING-IND/26) - Analysis, Design and Control of Chemical Processes
ICHI-02/B (ex ING-IND/27) - Chemical Technologies
IIET-01/A (ex ING-IND/31) - Electrical Engineering
IIND-08/A (ex ING-IND/32) - Power Electronic Converters, Electrical Machines and Drives
IIND-08/B (ex ING-IND/33) - Electrical Power Systems
IEGE-01/A (ex ING-IND/35) - Business and Management Engineering
of which at least **18 CFU** in the sectors:
IIND-06/A (ex ING-IND/08) - Fluid Machinery
IIND-06/B (ex ING-IND/09) - Energy Systems and Power Generation
IIND-07/A (ex ING-IND/10) - Thermal Engineering and Industrial Energy Systems

Art. 5
Procedures for access to the Degree Program (CdS)

1. The CCD of the Degree Program normally regulates the admission criteria and any scheduling of enrolments, except in cases subject to different provisions of law[2].
2. Verification of personal preparation is always mandatory, and only students who meet the curricular requirements can access it.
3. The assessment of curricular requirements is carried out by the CCD through analysis of the student's previous career. Enrolment in the Master's Degree Course is not permitted if the minimum curricular requirements are not met.
   If the minimum requirements are not met, the CCD assists the student by requesting him/her to be enrolled in individual teaching courses offered at the University and pass the relevant exams, to be carried out before enrolment.
   With reference to the minimum requirements of at least 18 CFU in the IIND-06/A, IIND-06/B and IIND-07/A sectors, the CCD can identify any equivalence of credits of scientific disciplinary sectors different from those indicated above on the basis of the contents of specific courses present in the student's previous career and strictly relevant to the topics of the aforementioned sectors.
   Students in possession of a L-9 degree or equivalent but with less than 18 CFU in the IIND-06/A, IIND-06/B and IIND-07/A sectors will be admitted to the Master's Degree course with the recommendation of an Individual Study Plan which involves a specific alignment path, without increasing total CFU.
   Following the verification of possession of the curricular requirements, it is also mandatory to verify the adequacy of the student's personal preparation, including the possession of adequate language skills.
   This verification is regulated by the CCD, according to guidelines established uniformly for all the Master's Degree Courses of the College of Engineering of the Polytechnic School and Basic Sciences.
   To this end, it is considered the average **M**, weighted on the basis of the number of CFU, of the grades (in thirtieths) scored in the exams necessary for obtaining the degree qualification which gives access to the Master's Degree Course. The student's personal preparation is considered adequate if **M ≥ 24**.
   Students who do not meet the previous criterium will have to take a specific admission test. The CdS website (http://meccanica.dii.unina.it/it/orientation-lm) contains information on how to reserve, carry out and pass the aforementioned test.
   As regards the verification of adequate linguistic skills, students who do not have a qualification obtained following attendance of a study course taught in Italian or English, and do not have linguistic certifications or qualifications documenting the knowledge of the Italian or English language at least at level B1 of the Common European Framework of Reference (CEFR), they must demonstrate, in an aptitude test, that they possess adequate comprehension and conversation skills in Italian or English.
   In particular, since to obtain the Master's degree the student must be able to fluently use a European Union language, in addition to the Italian language, the regulation provides in the study plan an adequate number of CFU (at least 3) to acquire 'Further linguistic knowledge, particularly in English. The achievement of this knowledge, at least at B2 level, will be certified using methods defined by the University Language Center (cla.unina.it). Students already in possession of an English certificate of at least B2 level at the time of enrolment require recognition for the

[2] National programmed access is regulated by L. 264/1999 and subsequent amendments and supplements.

purposes of Further Linguistic Knowledge with procedures established by the University Language Centre.

Art. 6
Teaching activities and university training credit (Teaching activities and CFU)

Each training activity, prescribed by the CdS detail sheet, is measured in CFU. Each CFU corresponds to 25 hours of overall training commitment[3] per student and includes the hours of teaching activities specified in the curriculum as well as the hours reserved for personal study or other individual training activities.

For the Degree Program covered by this Didactic Regulations, the hours of teaching specified in the curriculum for each CFU, established in relation to the type of training activity, are as follows [4]:

- Lecture or guided teaching exercises: 8 hours per CFU;
- Seminar: 8 hours per CFU;
- Laboratory activities or fieldwork: 8 hours per CFU;

For internship activities, each credit corresponds to 25 hours of overall training commitment [5].

The CFU corresponding to each training activity acquired by the student is awarded by satisfying the assessment procedures (examination, pass mark) indicated in the Course sheet relating to the course/activity attached to these Didactic Regulations.

Art. 7
Description of teaching methods

The didactic activity is carried out in modality of type a: Conventional Degree Programs

If necessary, the CCD decides which courses also include teaching activities offered online.

Some courses may also take place in seminar form and/or involve classroom exercises, language, and computer laboratories.

Detailed information on how each course is conducted can be found in the course sheets.

Art. 8
Testing of training activities[6]

1. The CCD, within the prescribed regulatory limits[7], establishes the number of examinations and other means of assessment that determine the acquisition of credits. Examinations are individual

[3] According to Art. 5, c. 1 of Italian Ministerial Decree No 270/2004, "25 hours of total commitment per student correspond to university training credits; a ministerial decree may justifiably determine variations above or below the aforementioned hours for individual classes, by a limit of 20 per cent".

[4] The number of hours considers the instructions in Art. 6, c. 5 of the RDA: "of the total 25 hours, for each CFU, are reserved: a) 5 to 10 hours for lectures or guided teaching exercises; b) 5 to 10 hours for seminars; c) 8 to 12 hours for laboratory activities or fieldwork, except in the case of training activities with a high experimental or practical content, and subject to different legal provisions or different determinations by DD.MM.".

[5] For Internship activities (Inter-ministerial Decree 142/1998), subject to further specific provisions, the number of working hours equal to 1 CFU may not be less than 25.

[6] Article 22 of the University Didactic Regulations.

[7] Pursuant to the DD.MM. 16.3.2007 in each Degree Programs the examinations or profit tests envisaged may not be more than 20 (Bachelor's Degrees; Art. 4. c. 2), 12 (Master's Degrees; Art. 4, c. 2), 30 (five-year single-cycle Degrees) or 36 (six-year single-cycle Degrees; Art. 4, c. 3). Pursuant to the RDA, Art. 13, c. 4, "the assessments that constitute an eligibility evaluation for activities referred to in Art. 10, c. 5, letters c), d), and e) of Ministerial Decree no. 270/2004, including the final examination for obtaining the degree, are excluded from the calculation." For Master's Degree Program and single-cycle Master's Degree Program, however, pursuant to the RDA, Art. 14, c. 7, "the assessments that constitute a progress evaluation for activities referred to in Art.10, c. 5, letters d) and e) of Ministerial Decree no.

and may consist of written, oral, practical, graphical tests, term papers, interviews, or a combination of these modes.

2. The examination procedures published in the course sheets and the examination schedule will be made known to students before the start of classes on the Department website.[8]
3. Examinations are held subject to booking, which is made electronically. In case the student is unable to book an exam for reasons that the President of the Board considers justifiable, the student may still be admitted to the examination, following those students already booked.
4. Before examination, the President of the Board of Examiners verifies the identity of the student, who must present a valid photo ID.
5. Examinations are marked out of 30. Examinations involving an assessment out of 30 shall be passed with a minimum mark of 18; a mark of 30 may be accompanied by honours by a unanimous vote of the Board. Examinations are marked out of 30 or with a simple pass mark. Assessments following tests other than examinations are marked out with a simple pass mark.
6. Oral exams are open to the public. If written tests are scheduled, the candidate has the right to see his/her paper(s) after correction.
7. The University Didactic Regulations govern Examination Boards [9].

Art. 9
Degree Program structure and Study Plan

1. The legal duration of the Degree Program is 2 years. It is also possible to enrol, based on a contract, in compliance with the provisions of Article 24 of the RDA.
   The student must acquire 120 CFU[10], attributable to the following Types of Training Activities (TAF):
   B) characterising,
   C) related or complementary,
   D) at the student's choice[11],
   E) for the final exam,
   F) further training activities.
2. The degree is awarded after having acquired 120 CFU by passing examinations, not exceeding 12 and the performance of other training activities.
   Unless otherwise provided for in the legal framework of University studies, examinations taken as part of basic, characterising, and related or supplementary activities, as well as activities chosen autonomously by the student (TAF D) are taken into consideration for counting purposes.

270/2004 are excluded from the exam count; the final examination for obtaining the Master's Degree and single-cycle Master's Degree is included in the maximum number of exams".

[8] Reference is made to Art. 22, c. 8, of the University Teaching Regulations, which states that "the Department or School ensures that the dates for progress assessments are published on the portal with reasonable advance notice, which normally cannot be less than 60 days before the start of each academic period, and that an adequate period of time is provided for exam registration, which is generally mandatory."

[9] Reference is made to Art. 22, paragraph 4 of the RDA according to which "Examination Boards and other assessments committees are appointed by the Director of the Department or by the President of the School when provided for in the School's Regulations. This function may be delegated to the CCD Coordinator. The Commissions comprise of the President and, if necessary, other professors or experts in the subject. In the case of active courses, the President is the course instructor, and in such cases, the Board can validly make decisions even in the presence of the President alone. In other cases, the President is a professor identified at the time of the Board's appointment. In the comprehensive evaluation of the overall performance at the conclusion of an integrated course, the professors in charge of the coordinated modules participate, and the President is appointed when the Commission is appointed."

[10] The total number of CFU for the acquisition of the relevant degree must be understood as follows: six-year single-cycle Degree, 360 CFU; five-year single-cycle Degree, 300 CFU; Bachelor's Degree, 180 CFU; Master's Degree, 120 CFU.

[11] Corresponding to at least 12 ECTs for Bachelor's Degrees and at least 8 CFU for Master's Degrees (Art. 4, c. 3 of Ministerial Decree 16.3.2007).

Examinations or assessments relating to activities independently chosen by the student may be taken into account in the overall calculation corresponding to one unit[12]. Tests constituting an assessment of suitability for the activities referred to in Article 10, paragraph 5, letters d) and e) of Ministerial Decree 270/2004[13] are excluded from the count. Integrated Courses comprising of two or more modules are subject to a single examination.

3. In order to acquire the CFU relating to independent choice activities, the student is free to choose among all the Courses offered by the University, provided they are consistent with the training project. This consistency is assessed by the Didactic Coordination Commission. Also, for the acquisition of the CFU relating to autonomous choice activities, the "passing the exam or other form of profit verification" is required (Art. 5, c. 4 of Ministerial Decree 270/2004).
4. The study plan summarises the structure of the Degree Program, listing the envisaged teachings broken down by course year and, in case, by curriculum. At the end, the propedeuticities envisaged by the Degree Program are listed. The study plan offered to students, with an indication of the scientific-disciplinary sectors and the area to which they belong, of the credits, of the type of educational activity, is set out in Annex 1 to these Didactic Regulations.
5. Pursuant to Art. 11, paragraph 4-bis, of Ministerial Decree 270/2004, it is possible to obtain the Degree according to an individual study plan that also includes educational activities different from those specified in the Didactic Regulations, as long as they are consistent with the CdS detail sheet of the academic year of enrollment. The individual study plan is approved by the CCD.

The Study Course is associated with the Minor training course in "Green Technologies", governed by the Regulations reported in Annex 3. It is achieved through the presentation of an individual study plan which provides for the acquisition of at least 15 additional extracurricular CFUs (135 CFUs in total), together with an appropriate choice of at least 15 curricular CFUs. Annex 1 defines, for each of the 4 paths indicated above, the specific curricular and extracurricular training activities (and the related types, TAF) necessary for its achievement. Further information on the Minor is reported in Annex 3.

Art. 10
Attendance requirements[14]

1. In general, attendance of lectures is strongly recommended but not compulsory.
   In the case of individual courses with compulsory attendance, this option is indicated in the relative teaching/activity course sheet available in Annex 2.

[12] Pursuant to the D.M. 386/2007.

[13] Art. 10, c. 5 of Ministerial Decree. 270/2004: "In addition to the qualifying training activities, as provided for in paragraphs 1, 2 and 3, Degree Programs shall provide for: a) training activities autonomously chosen by the student as long as they are consistent with the training project [TAF D]; b) training activities in one or more disciplinary fields related or complementary to the basic and characterising ones, also with regard to context cultures and interdisciplinary training [TAF C]; c) training activities related to the preparation of the final exam for the achievement of the degree and, with reference to the degree, to the verification of the knowledge of at least one foreign language in addition to Italian [TAF E]; d) training activities, not envisaged in the previous points, aimed at acquiring additional language knowledge, as well as computer and telematic skills, relational skills, or in any case useful for integration in the world of work, as well as training activities aimed at facilitating professional choices, through direct knowledge of the job sector to which the qualification may give access, including, in particular, training and guidance programs referred to in Decree no. 142 of 25 March 1998 of the Ministry of Labour [TAF F]; e) in the hypothesis referred to in Article 3, paragraph 5, training activities relating to internships and apprenticeships with companies, public administrations, public or private entities including those of the third sector, professional orders and colleges, on the basis of appropriate agreements".

[14] Art. 22, c. 10 of the University Didactic Regulations.

2. If the lecturer envisages a different syllabus modulation for attending and non-attending students, this is indicated in the individual Course details published on the CdS web page and on the teacher's UniNA website.
3. Attendance at seminar activities that award training credits is compulsory. The relative modalities for the attribution of CFU are the responsibility of the CCD.

Art. 11
Prerequisites and prior knowledge

1. The list of incoming and outgoing propedeuticities (necessary to sit a particular examination) can be found in the Annex 1 and in the teaching/activity course sheets (Annex 2).
2. Any prior knowledge deemed necessary is indicated in the individual Teaching Schedule published on the course webpage and on the teacher's UniNA website.

Art. 12
Degree Program Calendar

The Degree Program calendar can be found on the Department website well before the start of the activities (Art. 21, c. 5 of the RDA).

Art. 13
Criteria for the recognition of credits earned in other Degree Programs in the same Class[15]

For students coming from Degree Programs of the same class, the Didactic Coordination Commission ensures the full recognition of CFU, when associated with activities that are culturally compatible with the training Degree Program, acquired by the student at the originating Degree Program, according to the criteria outlined in Article 14 below. Failure to recognise credits must be adequately justified. It is without prejudice to the fact that the number of credits relating to the same scientific-disciplinary sector directly recognised by the student may not be less than 50% of those previously achieved.

Article 14
Criteria for the recognition of credits acquired in Degree Programs of different classes, in university or university-level Degree Programs, through single courses, at online Universities and in international Degree Programs[16]; criteria for the recognition of credits acquired in extra-curricular activities

1. With regard to the criteria for the recognition of CFU acquired in Degree Programs of different Classes, in university or university-level Degree Programs, through single courses, at online Universities and in International Degree Programs, the credits acquired are recognised by the CCD on the basis of the following criteria:
   - analysis of the activities carried out;
   - evaluation of the congruity of the disciplinary scientific sectors and of the contents of the training activities in which the student has earned credits with the specific training objectives of the Degree Program and of the individual training activities to be recognised.

   Recognition is carried out up to the number of credits envisaged by the didactic system of the Degree Program. Failure to recognise credits must be adequately justified. Pursuant to Art. 5, c.

[15] Art. 19 of the University Didactic Regulations.
[16] Art. 19 of the University Didactic Regulations.

5-bis, of Ministerial Decree 270/2004, it is also possible to acquire CFU at other Italian universities on the basis of agreements established between the concerned institutions, in accordance with the regulations current at the time [17].

2. Any recognition of CFU relating to examinations passed as single courses may take place within the limit of 36 CFU, upon request of the interested party and following the approval of the CCD. Recognition may not contribute to the reduction of the legal duration of the Degree Program, as determined by Art. 8, c. 2 of Ministerial Decree 270/2004, except for students who enrol while already in possession of a degree of the same level[18].
3. With regard to the criteria for the recognition of CFU acquired in extra-curricular activities, pursuant to Art. 3, par. 2, of Ministerial Decree (D.M.) 931/2024, within the limit of 48 CFU (Bachelor's Degrees and single-cycle Master's Degrees), or 24 CFU (Master's Degrees), the following activities may be recognised (Art. 2 of D.M. 931/2024):
   - Professional knowledge and skills, certified in accordance with the current regulations as well as knowledge and skills acquired in post-secondary-level training activities.
   - Training activities carried out in the cycles of study at the public administration training institutions as well as knowledge and skills acquired in post-secondary-level training activities, which the University contributed to developing and implementing.
   - Achievement of an Olympic or Paralympic medal or the title of absolute world champion, absolute European champion or absolute Italian champion in disciplines recognized by the Italian National Olympic Committee or the Italian Paralympic Committee.

Art. 15
Criteria for enrolment in individual teaching courses

Enrolment in individual teaching courses, provided for by the University Didactic Regulations[19], is governed by the "University Regulations for enrolment in individual teaching courses activated as part of the Degree Program"[20].

Article 16
Features and modalities for the final examination

The Master's Degree in Mechanical Engineering for Energy and Environment is achieved after passing a final test, consisting of the evaluation by an academic commission of the thesis, prepared by the student under the guidance of one or more academic supervisors and with the possible correlation of experts external to the University. The thesis concerns theoretical, methodological, numerical or experimental activities. Activities carried out in research laboratories external to the university, as well as in Italian and foreign companies and institutions, may contribute to the preparation of the thesis, if those are carried out during an external internship under the supervision of an academic tutor. External tutors who have supervised the student on specific topics of the internship may be invited to the thesis discussion as co-supervisors, without being part of the examination commission. The written report and the discussion may be developed in English and must demonstrate the originality of the work carried out, the knowledge of the investigated topics, the maturity acquired, the ability to operate autonomously and a good level of communication skills, including the effective use of numerical tools.
The final test is taken by the Candidate before a Commission chaired by the Coordinator of the Study Course (or in case of his unavailability, by the most senior professor in the Commission) and consists

[17] Art. 6, c. 9 of the University Didactic Regulations.
[18] Art. 19, c. 4 of the University Didactic Regulations.
[19] Art. 19, c. 4 of the University Didactic Regulations.
[20] R.D. No. 348/2021.

of the presentation of the work carried out under the guidance of a supervisor professor and the subsequent discussion with the members of the Commission.
The supervisor, possibly assisted by co-supervisors, performs the following functions:

- certifies the accomplishment of any preparatory activities (intra-moenia or extra-moenia internships, in agreement with the academic tutor, if this is different from the supervisor);
- evaluates the overall progress of the activities aimed at preparing the thesis manuscript;
- guides the student in preparing the degree project;
- assists the student in preparing for the degree exam.

The candidate is allowed to use of an audio-visual support, to be shown publicly, or, alternatively, to draw up a summary booklet, to be delivered in copy to each member of the Commission.
At the end of the presentation, each professor can ask the candidate observations and questions related to the thesis work. The presentation usually takes 15 minutes.
The 12 CFU attributed to the final examination are divided into:

- 11 CFU: activities for the preparation of the degree thesis
- 1 CFU: degree examination

Article 17
Guidelines for traineeship and internship

1. Students enrolled in the Degree Program may decide to carry out internships or training periods with organisations or companies that have an agreement with the University. Traineeship and internship are compulsory and contribute to the award of credits for the other training activities chosen by the student and included in the study plan, as provided for by Art. 10, par. 5, letters d and e, of Ministerial Decree 270/2004[21].
2. The CCD regulates the modalities and characteristics of traineeship and internship with specific regulations.
3. The University of Naples Federico II, through the Orientation and Placement Service of the Polytechnic and Basic Sciences School (https://www.jobservice.unina.it), ensures constant contact with the work world to offer students and graduates of the University concrete opportunities for internships and work experience and to promote their professional integration.

Article 18
Disqualification of student status[22]

A student who has not taken any examinations for eight consecutive academic years incurs forfeiture unless his/her contract stipulates otherwise. In any case, forfeiture shall be notified to the student by certified e-mail or other suitable means attesting to its receipt.

Article 19
Teaching tasks, including supplementary teaching, guidance, and tutoring activities

1. Professors and researchers carry out the teaching load assigned to them in accordance with the provisions of the RDA and the Regulations on the teaching and student service duties of professors and researchers and on the procedures for self-certification and verification of actual performance[23].

[21] Traineeships ex letter d can be both internal and external; traineeships ex letter e can only be external.
[22] Art. 24, c. 5 of the University Didactic Regulations.
[23] R.D No. 2482//2020.

2. Professors and researchers must guarantee at least two hours of reception every 15 days (or by appointment in any case granted no longer than 15 days) and, in any case, guarantee availability by e-mail.
3. The tutoring service has the task of orienting and assisting students throughout their studies and of removing the obstacles that prevent them from adequately benefiting from attending courses, also through initiatives tailored to the needs and aptitudes of individuals.
4. The University ensures guidance, tutoring and assistance services and activities to welcome and support students. These activities are organised by the Schools and/or Departments under the coordination of the University, as established by the RDA in Article 8.

Article 20
Evaluation of the quality of the activities performed

1. The Didactic Coordination Commission implements all the quality assessment forms of teaching activities envisaged by the regulations in force according to the indications provided by the University Quality Presidium.
2. In order to guarantee the quality of teaching to the students and to identify the needs of the students and all stakeholders, the University of Naples Federico II uses the Quality Assurance (QA)[24] System, developed in accordance with the document "Self-evaluation, Evaluation and Accreditation of the Italian University System" of ANVUR, using:
   - surveys on the degree of placement of graduates into the world of work and on post-graduate needs;
   - data extracted from the administration of the questionnaire to assess student satisfaction for each course in the curriculum, with questions relating to the way the course is conducted, teaching materials, teaching aids, organisation, facilities.

   The requirements deriving from the analysis of student satisfaction data, discussed, and analysed by the Teaching Coordination Committee and the Joint Teachers' and Students' Committee (CPDS), are included among the input data in the service design process and/or among the quality objectives.
4. The QA System developed by the University implements a process of continuous improvement of the objectives and of the appropriate tools to achieve them, ensuring that planning, monitoring, and self-assessment processes are activated in all the structures to allow the prompt detection of problems, their adequate investigation, and the design of possible solutions.
5.

Article 21
Final Rules

The Department Council, on the proposal of the CCD, submits any proposals to amend and/or supplement these Rules for consideration by the Academic Senate.

Article 22
Publicity and Entry into Force

1. These Rules and Regulations shall enter into force on the day following their publication on the University's official notice board; they shall also be published on the University website. The same forms and methods of publicity shall be used for subsequent amendments and additions.
2. Annex 1 (CdS structure), Annex 2 (Teaching/Activity course sheets) and Annex 3 (Regulations of Minor in “Green Technologies”) are integral parts of this Didactic Regulations.

[24] The Quality Assurance System, based on a process approach and adequately documented, is designed in such a way as to identify the needs of the students and all stakeholders, and then translate them into requirements that the training offer must meet.

ANNEX 1

DEGREE PROGRAM DIDACTIC REGULATIONS

MECHANICAL ENGINEERING FOR THE ENERGY AND THE ENVIRONMENT

CLASS LM-33

School: Polytechnical and Basic Sciences

Department: Industrial Engineering

Didactic Regulations in force since the academic year 2025 - 2026

STUDY PLAN

KEY

Type of Educational Activity (TAF):

B = Characterising
C = Related or Supplementary
D = At the student's choice
E = Final examination and language knowledge
F = Further training activities

Introduction

The Master's Degree Course in Mechanical Engineering for the Energy and the Environment (LM-IMEA) (http://meccanica.dii.unina.it/en/info-lmea) is made up of four study plans (**curricula**), called ***"Innovative Energy Systems"***, ***"Advanced Energy Management", "Propulsion Systems",*** *held in Italian Language, and* ***"Sustainable Energy"***, held in English, made up of 120 CFU, to be chosen when presenting the Study Plan.

Students enrolled in the Master's Degree are offered the opportunity to select an interdisciplinary curriculum called **Minor** in "***Green Technologies***", which partially overlaps with the standard curricula. The latter is normally achieved through the acquisition (**at least one year more than the Course duration**) of further **15 extra-curricular CFUs** (135 CFUs in total), **together with an appropriate selection of at least 15 curricular CFUs**, depending on the curriculum chosen. The attached **notes** present the ways of choosing the total of 30 CFUs (15 extra-curricular and 15 curricular) that are compulsory to obtain the **Minor** in "***Green Technologies***", which is finally certified by an "Open Badge" (https://bestr.it/badge/show/2728).

CURRICULA AND LANGUAGES

	Curriculum	Acronym	Language
1	**Sistemi Energetici Innovativi** ***Innovative Energy Systems***	***SEI***	Italian
2	**Gestione Avanzata dell'Energia** ***Advanced Energy Management***	***GAE***	Italian
3	**Sistemi Propulsivi** ***Propulsion Systems***	***SP***	Italian
4	**Sustainable Energy** ***Energia Sostenibile***	***SE***	English
5	***Minor in Green Technologies***	***MGT***	Italian/English

1) Curriculum Innovative Energy Systems

I Year

Title Course	SSD	Module	Credits	Hours	Type Activities	Course Modalities	TAF	Disciplinary area	Mandatory/ optional
Mandatory curricular educational activities		unique	18	144	Lecture	In person	B	Mechanical engineering	2 Mandatory in **Table O**
Related/integrative educational activities of the student's choice (**note a**)		unique	15	120	Lecture	In person	C	Related/ integrative activities	2 chosen from **Table A**
Curricular educational activities of the student's choice (**note b**)		unique	0-18 (^)	0-144	Lecture	In person	B	Mechanical engineering	0-2 chosen from **Table B1**
Students' autonomous choice (**note d**)		unique	0-15 (°)	0-120	Lecture	In person	D		0-2 chosen from **Table D1**
Additional Language Proficiency (**note e**, **note h**)			3				F		Mandatory

II Year

Title Course	SSD	Module	Credits	Hours	Type Activities	Course Modalities	TAF	Disciplinary area	Mandatory/ Optional
Mandatory curricular educational activities in the curriculum		unique	24	192	Lecture	in person	B	Mechanical engineering	3 Mandatory in **Table O1**
Curricular educational activities of the student's choice (**note b**)		unique	0-18 (^)	0-144	Lecture	in person	B	Mechanical engineering	0-2 chosen from **Table B1**
Curricular educational activities of the student's choice (**note c**)		unique	6	48	Lecture	in person	B	Mechanical engineering	1 chosen from **Table C1**
Students' autonomous choice (**note d**)		unique	0-15 (°)	0-120	Lecture	in person	D		0-2 chosen from **Table D1**
Internship (**note f**)			9		Internship		F		Mandatory
Final exam (**note g**, **note h**)			12				E		Mandatory

For the Minor in Green Technologies

Extra-curricular course (**note h)**		unique	6,9	48,72	Lecture	in person	C,D		1 Mandatory in **Table A.TG**
Extra-curricular course (**note h)**		unique	6,9	48,72	Lecture	in person	B,C,D		1 chosen in **Tables B.TG** and **C.TG**
Extra-curricular course (**note h)**			3				F		Courses/Seminaries organized by Minor associated Courses

(^) Curricular activities in **note b** fulfil a **total requirement of 18 CFU,** divided between I and II year, depending on the student's choices

(°) Autonomous choices activities in **note d** fulfil a **total requirement of 15 CFU**, divided between I and II year, depending on the student's choices

2) Curriculum Advanced Energy Management

I Year

Title Course	SSD	Module	Credits	Hours	Type Activities	Course Modalities	TAF	Disciplinary area	Mandatory/ optional
Mandatory curricular educational activities in the curriculum		unique	18	144	Lecture	in person	B	Mechanical engineering	2 Mandatory in **Table O**
Mandatory curricular educational activities in the curriculum		unique	15	120	Lecture	in person	B	Mechanical engineering	2 Mandatory in **Table O2**
Related/integrative educational activities of the student's choice (**note a**)		unique	15	120	Lecture	in person	C	Related/ integrative activities	2 chosen from **Table A**
Curricular educational activities of the student's choice (**note b**)		unique	0-18 (^)	0-144	Lecture	in person	B	Mechanical engineering	0-2 chosen from **Table B2**
Students' autonomous choice (**note d**)		unique	0-15 (°)	0-120	Lecture	in person	D		0-2 chosen in **Table D2**
Additional Language Proficiency (**note e**, **note h**)			3				F		Mandatory

II Year

Title Course	SSD	Module	Credits	Hours	Type Activities	Course Modalities	TAF	Disciplinary area	Mandatory/ optional
Mandatory curricular educational activities in the curriculum		unique	15	120	Lecture	in person	B	Mechanical engineering	2 Mandatory in **Table O2**
Curricular educational activities of the student's choice (**note b**)		unique	0-18 (^)	0-144	Lecture	in person	B	Mechanical engineering	0-2 chosen from **Table B2**
Students' autonomous choice (**note d**)		unique	0-15 (°)	0-120	Lecture	in person	D		0-2 chosen from **Table D2**
Internship (**note f**)			9		Internship		F		Mandatory
Final exam (**note g**, **note h**)			12				E		Mandatory

For the Minor in Green Technologies

Extra-curricular course (**note h)**		unique	6,9	48,72	Lecture	in person	C,D		1 Mandatory in **Table A.TG**
Extra-curricular course (**note h)**		unique	6,9	48,72	Lecture	in person	B,C,D		1 chosen in **Tables B.TG** and **C.TG**
Extra-curricular course (**note h)**			3				F		Courses/Seminaries organized by Minor associated Courses

(^) Curricular activities in **note b** fulfil a **total requirement of 18 CFU,** divided between I and II year, depending on the student's choices

(°) Autonomous choices activities in **note d** fulfil a **total requirement of 15 CFU**, divided between I and II year, depending on the student's choices

3) Curriculum Propulsion Systems

I Year

Title Course	SSD	Module	Credits	Hours	Type Activities	Course Modalities	TAF	Disciplinary area	Mandatory/ optional
Mandatory curricular educational activities in the curriculum		unique	18	144	Lecture	in person	B	Mechanical engineering	2 Mandatory in **Table O**
Mandatory curricular educational activities in the curriculum		unique	15	120	Lecture	in person	B	Mechanical engineering	2 Mandatory in **Table O3**
Related/integrative educational activities of the student's choice (**note a**)		unique	15	120	Lecture	in person	C	Related/ integrative activities	2 chosen from **Table A**
Students' autonomous choice (**note d**)		unique	0-15 (°)	0-120	Lecture	in person	D		0-2 chosen from **Table D3**
Additional Language Proficiency (**note e**, **note h**)			3				F		Mandatory

II Year

Title Course	SSD	Module	Credits	Hours	Type Activities	Course Modalities	TAF	Disciplinary area	Mandatory/ optional
Mandatory curricular educational activities in the curriculum		unique	9	72	Lecture	in person	B	Mechanical engineering	1 Mandatory in **Table O3**
Curricular educational activities of the student's choice (**note b**)		unique	18	144	Lecture	in person	B	Mechanical engineering	2 chosen from **Table B3**
Curricular educational activities of the student's choice (**note c**)		unique	6	48	Lecture	in person	B	Mechanical engineering	1 chosen from **Table C3**
Students' autonomous choice (**note d**)		unique	0-15 (°)	0-120	Lecture	in person	D		0-2 chosen in **Table D3**
Internship (**note f**)			9		Internship		F		Mandatory
Final exam (**note g**, **note h**)			12				E		Mandatory

For the Minor in Green Technologies

Extra-curricular course (**note h)**		unique	6,9	48,72	Lecture	in person	C,D		1 Mandatory in **Table A.TG**
Extra-curricular course (**note h)**		unique	6,9	48,72	Lecture	in person	B,C,D		1 chosen in **Tables B.TG** and **C.TG**
Extra-curricular course (**note h)**			3				F		Courses/Seminaries organized by Minor associated Courses

(°) Autonomous choices activities in **note d** fulfil a **total requirement of 15 CFU**, divided between I and II year, depending on the student's choices

4) Curriculum Sustainable Energy

I Year

Title Course	SSD	Module	Credits	Hours	Type Activities	Course Modalities	TAF	Disciplinary area	Mandatory/ optional
Mandatory curricular educational activities in the curriculum		unique	18	144	Lecture	in person	B	Mechanical engineering	2 Mandatory in **Table O4a**
Mandatory curricular educational activities in the curriculum		unique	6+6	96	Lecture	in person	B	Mechanical engineering	1 Mandatory in **Table O4b**
Related/integrative educational activities of the student's choice (**note a**)		unique	15	120	Lecture	in person	C	Related/ integrative activities	2 chosen from **Table A4**
Students' autonomous choice (**note d**)		unique	0-15 (°)	0-120	Lecture	in person	D		0-2 chosen from **Table D4**
Additional Language Proficiency (**note e**, **note h**)			3				F		Mandatory

II Year

Title Course	SSD	Module	Credits	Hours	Type Activities	Course Modalities	TAF	Disciplinary area	Mandatory/ optional
Mandatory curricular educational activities in the curriculum		unique	6+6	96	Lecture	in person	B	Mechanical engineering	1 Mandatory in **Table O4b**
Curricular educational activities of the student's choice (**note b4**)		unique	12	96	Lecture	in person	B	Mechanical engineering	2 chosen from **Table B4**
Curricular educational activities of the student's choice (**note c4**)		unique	12	96	Lecture	in person	B	Mechanical engineering	2 chosen from **Table C4**
Students' autonomous choice (**note d**)		unique	0-15 (°)	0-120	Lecture	in person	D		0-2 chosen from **Table D4**
Internship (**note f**)			9		Internship		F		Mandatory
Final exam (**note g**, **note h**)			12				E		Mandatory

For the Minor in Green Technologies

Extra-curricular course (**note h)**		unique	6,9	48,72	Lecture	in person	C,D		1 Mandatory in **Table A.TG**
Extra-curricular course (**note h)**		unique	6,9	48,72	Lecture	in person	B,C,D		1 chosen in **Tables B.TG** and **C.TG**
Extra-curricular course (**note h)**			3				F		Courses/Seminaries organized by Minor associated Courses

(°) Autonomous choices activities in **note d** fulfil a **total requirement of 15 CFU**, divided between I and II year, depending on the student's choices

List of propaedeuticities

No propaedeuticities are planned

Note

a) By choice (15 CFU), within the framework of integrative educational curricular activities (TAF C), listed in **Table A** for the ***IES***, ***GAE*** and ***SP*** curricula, and in **Table A4** for the ***SE*** curricula. For the ***MGT*** curricula, the related and integrative activities **must** include at least one course of 6 CFUs, chosen from the TAF C courses listed in **Tables A.TG** and **B.TG**

b) By choice (18 CFU in total, divided between I and II years), within the framework of the characterizing curricular activities (TAF B) listed in **Tables B1, B2, B3,** referring to the ***IES***, ***GAE***, and ***SP*** curricula, respectively**.**

c) By choice (6 CFU), within the framework of the characterizing curricular activities (TAF B) reported in **Tables C1 e C3,** related to the ***IES*** and ***SP*** curricula, respectively.

b4) By choice (12 CFU in total, during the II year), within the framework of the characterizing educational curricular activities (TAF B) listed in **Table B4,** related to the ***SE*** curriculum.

c4) By choice (12 CFU in total, during the II year), within the characterizing educational curricular activities (TAF B) reported in **Table C4,** related to the curriculum ***SE***.

d) By choice (15 CFU in total, divided between I and II years), within the framework of the characterizing educational curricular activities proposed autonomous choice of the student (TAF D), reported in **Tables D1, D2, D3, D4** and related headers, referring to the ***IES***, ***GAE, SP*** and ***SE*** curricula, respectively.

e) Additional Language Proficiency: students who don't have an English Language Certificate at least at a B2 level according to the Common European Framework of Reference for Languages (CEFR), must include in their study plan a number of CFUs for the additional language skills to guarantee this level (3 CFUs). These credits can be obtained at external centres or at the University Language Centre (cla.unina.it) and will be recognized when the certificate is presented. Enrolled students who already have an English Language Certificate of at least B2 level can request the recognition of the Additional Language Proficiency (3 CFUs)

f) The internship can be either extramoenia or intramoenia. The extramoenia internship is carried out in companies, research centers, or other public/private bodies, whose objective is to acquire specialized knowledge thanks to the coaching of workers employed in design, production and management activities of manufacturing plants or research, in order to have a first approach to the professional world. The intramoenia internship is carried out in University research laboratories, with the aim of acquiring specific knowledge thanks to coaching from faculty and research staff, related to research and development activities. In all the cases, the internship must be certified with a work internship booklet and an AC model to be filled in by the University tutor. In order to start up the internship, a specific procedure is mandatory, together with health and safety duties, as described in detail on the Study Course website: http://meccanica.dii.unina.it/en/tirocinio-lmea

g) The thesis work can also be carried out in companies located in Italy or abroad. It will be carried out under the direct responsibility of a Professor of the Engineering Didactic Area of the Università degli Studi di Napoli Federico II (the procedures for assigning the thesis supervisor to the student are specified in the Degree Program Didactic Regulation) and, if applicable, under the supervision of a co-tutor from the company. The procedures for assigning the company co-tutor are specified in the Degree Program Didactic Regulation and also is specific Agreements. For the ***MGT*** curriculum, the thesis must be written on **topics related to the subjects of the Minor**.

h) The student who wants to enroll in the ***MGT*** educational project curriculum, together with the constraints previously reported in the various notes, must fulfil the following criteria:

- **Acquisition of at least 15 curricular CFUs**, (not belonging to key courses), selected as follow:
  - At least 6 CFUs of related/integrated activities (TAF C) valid for the ***MGT*** (**note a**)
  - At least 6 CFUs of students' autonomous choice (TAF D) valid for the ***MGT*** (**note d**)
- **Acquisition of at least 15 extra-curricular CFUs***,* to be completed no later than one more year than the standard duration of the Master's Degree, at no extra cost for the student, to be chosen as follows:
  - At least 6 CFUs of courses (TAF C or D) from **Table A.TG**.
  - At least 6 CFUs of from any course valid for the ***MGT***, marked with (*) in Tables referring to the individual curricula presented in subsequent pages in this document.
  - The rest (0-3 CFUs) to be achieved through seminar activities organized by the Degree Course or by the University, related to economics and management aspects, with a focus on issues connected to energy, environment, and sustainability.

If the conditions reported above are met, then the **study plan is automatically approved**. In this case, the student only has to communicate **the curriculum chosen (*IES*, *GAE*, *SP* or *SE*)** to the Students Offices of the Engineering Educational Area of the Polytechnic and Basic Sciences, together with eventual personalized autonomous choice courses.

More customized solutions can be developed by means of an **individual study plan**, in compliance with the Didactic regulation and Teaching System Regulations. The Didactic Program Degree Coordination Committee reserves the right to approve or not the individual study plan, on the basis of a clear motivation from the student, with references to the legislation in force. In all the cases, an exam can only be taken only after the corresponding course has been completed in the Academic Year in which the study plan was submission.

In the tables of educational activities on the following pages, courses with first title in Italian are offered in Italian language, while those with first title in English are offered in English.

Courses from which mutations are carried out	Acronym
Master's degree in mechanical engineering for Design and Production	LM-IMPP
Master's degree in electrical engineering	LM-IELT
Master's degree in chemical engineering	LM-ICHI
Master's degree in aerospace engineering	LM-IAER
Master's degree in Autonomous Vehicle Engineering	LM-MOVE
Master's degree in management engineering	LM-IGES
Master's degree in Materials Science	LM-IMAT
Master's degree in Transportation Engineering and Mobility	LM-TEAM
Master's degree in environmental engineering	LM-IAMT
Master's degree in computer science engineering	LM-IINF
Bachelor's degree in computer science engineering	L-IINF

TABLES LISTING THE MANDATORY EDUCATIONAL ACTIVITIES FOR THE CURRICULA SEI, GAE and SP

Table O) - Mandatory curricular educational activities (18 CFU), common to the curricula SEI, GAE and SP, TAF B

Course or Educational activity	Year/ Semester	CFU	SSD	TAF	Disciplinary area
Trasmissione del Calore *Heat Transfer*	I / I	9	IIND-07/A (ex ING-IND/10)	B	Mechanical Engineering
Termofluidodinamica delle Macchine *Aero-Thermodynamics of Fluid Machinery*	I / II	9	IIND-06/A (ex ING-IND/08)	B	Mechanical Engineering

TABLE OF THE RELATED AND INTEGRATIVE ACTIVITIES OF THE STUDENT'S CHOICE

Table A) - Related/integrative educational activities of the student's choice (15 CFU), common to the curricula SEI, GAE and SP, TAF C

Course or Educational activity	Year/ Semester	CFU	SSD	TAF	Disciplinary area
Sistemi Elettrici per l'Energia *Electric Power Systems*	I / I	9	IIND-08/B (ex ING-IND/33)	C	Related/integrative educational activities
Regolazione delle Centrali Elettriche *Electrical Power Plant Regulation*	I / II	6	IIND-08/B (ex ING-IND/33)	C	Related/integrative educational activities
Economia ed Organizzazione Aziendale *Economics and Business Organization*	I / I	6	IEGE-01/A (ex ING-IND/35)	C	Related/integrative educational activities
Gestione Aziendale *Business Management* Gestione Aziendale (*Business Management*) Laboratorio di Gestione Aziendale (*Business Management Lab*)	 I / II I / II	 6 3	IEGE-01/A (ex ING-IND/35)	C	Related/integrative educational activities
Combustione *Combustion*	I / I	9	ICHI-02/A (ex ING-IND/25)	C	Related/integrative educational activities
Inquinanti Atmosferici da Attività Antropiche *Pollutant Formation and Control*	I / II	6	ICHI-02/A (ex ING-IND/25)	C	Related/integrative educational activities
For the *MGT* curriculum: TAF C courses (6 or 9 CFU) from Tables A.TG, B.TG		6,9		C	Related/integrative educational activities

Table A4) - Related/integrative educational activities of the student's choice (15 CFU), for the curricula SE, TAF C

Course or Educational activity	Year/ Semester	CFU	SSD	TAF	Disciplinary area/ Mutations
Energy Management for Transportation (*) *Gestione dell'Energia per i Trasporti*	I o II / I	9	IIND-08/A (ex ING-IND/32)	C	Related/integrative educational activities LM-TEAM
Electrical Technologies for the Ecological Transition *Tecnologie elettriche per la transizione ecologica* (*) Electric Energy Storage (*Accumulo di Energia Elettrica*) Electric Mobility and Generation from Renewables (*Mobilità Elettrica e Generazione da Fonti Rinnovabili*)	 I o II / II I o II / II	 3 3	 IIET-01/A (ex ING-IND/31) IIND-08/A (ex ING-IND/32)	C	Related/integrative educational activities LM-IELT
Smart, Resilient and Sustainable City (*) *Città Intelligente, Resiliente e Sostenibile*	I o II / I	9	CEAR-12/A (ex ICAR/20)	C	Related/integrative educational activities LM-IAMT
Circular Bioeconomy for the ecological transition (*) *Bioeconomia Circolare per la Transizione Ecologica*	I o II / II	6	CEAR-02/A (ex ICAR/03)	C	Related/integrative educational activities LM-IAMT
Sustainable Combustion Processes for Energy Conversion *Processi di Combustione Sostenibili per la Conversione dell'Energia*	I / I	9	ICHI-02/A (ex ING-IND/25)	C	Related/integrative educational activities
Industrial Ecology and Green Engineering (*) *Ecologia Industriale e Ingegneria Verde*	I o II / II	6	ICHI-02/A (ex ING-IND/25)	C	Related/integrative educational activities LM-ICHI

(*) Course valid for the ***MGT*** curriculum, too

Curriculum INNOVATIVE ENERGY SYSTEMS

Table O1) - Mandatory curricular educational activities in the curriculum (24 CFU), TAF B

Course or Educational activity	Year/ Semester	CFU	SSD	TAF	Disciplinary area
Turbomacchine per l'Energia Eolica *Turbomachinery for Wind Energy*	II / I	6	IIND-06/A (ex ING-IND/08)	B	Mechanical Engineering
Tecniche e Modelli per la Refrigerazione *Techniques and Models for Refrigeration*	II / I	9	IIND-07/A (ex ING-IND/10)	B	Mechanical Engineering
Impianti con Turbina a Gas *Gas Turbine Based Power Plants*	II / II	9	IIND-06/A (ex ING-IND/08)	B	Mechanical Engineering

Table B1) - Curricular educational activities of the student's choice (18 CFU), TAF B

Course or Educational activity	Year/ Semester	CFU	SSD	TAF	Disciplinary area
Impianti di Generazione Termica *Heat Generation Plants*	I / I	9	IIND-06/B (ex ING-IND/09)	B	Mechanical Engineering
Acustica Applicata *Applied Acoustics*	II / I	9	IIND-07/A (ex ING-IND/10)	B	Mechanical Engineering
Progetto di Macchine *Fluid Machinery Design Principles*	II / II	9	IIND-06/A (ex ING-IND/08)	B	Mechanical Engineering
Impianti di Climatizzazione *Heating and Cooling systems*	II / II	9	IIND-07/A (ex ING-IND/10)	B	Mechanical Engineering

Table C1 - Curricular educational activities of the student's choice (6 CFU), TAF B

Course or Educational activity	Year/ Semester	CFU	SSD	TAF	Disciplinary area
Impianti per l'Energia Solare *Solar Energy Technologies*	II / II	6	IIND-07/A (ex ING-IND/10)	B	Mechanical Engineering
Gestione di Sistemi Termodinamici Avanzati *Management of Advanced Thermodynamic Systems*	II / II	6	IIND-07/A (ex ING-IND/10)	B	Mechanical Engineering

Table D1) – Educational activities suggested for the student's autonomous choice (15 CFU), TAF D
Classes from TAF B <u>for SEI, GAE and SP curricula</u>, or classes from Tables A.TG, B.TG and C.TG, or:

Course or Educational activity	Year/ Semester	CFU	SSD	TAF	Disciplinary area / Mutations
Modellazione Geometrica per l'Energia e l'Ambiente *Geometrical Modelling for Energy and Environment*	I / II	9	IIND-03/B (ex ING-IND/15)	D	Specific for LM-IMEA
Plasmi e Fusione Termonucleare *Plasmas and Thermonuclear Fusion*	I / I	9	IIET-01/A (ex ING-IND/31)	D	LM-IELT
Progettazione Assistita di Strutture Meccaniche *Computer Aided Design of Mechanical Structures*	I / I	9	IIND-03/A (ex ING-IND/14)	D	LM-IMPP
Tecnologie Speciali *Non-Conventional Manufacturing Technologies*	I / II	9	IIND-04/A (ex ING-IND/16)	D	LM-IMPP
Sicurezza e Manutenzione degli Impianti Industriali *Safety and Maintenance of Industrial Plants*	I / II	9	IIND-05/A (ex ING-IND/17)	D	LM-IMPP
Controlli Automatici *Automatic Controls*	I / II	9	IINF-04/A (ex ING-INF/04)	D	L-IINF
Mathematical Models and Computational Methods for Engineering *Modelli Matematici e Metodi Computazionali per l'Ingegneria*	I / I	9	MATH-04/A (ex MAT/07)	D	Specific for LM-IMEA
For the *MGT* curriculum: TAF D course (6 or 9 CFU) from Table C.TG (*)		6,9		D	

(*) The sum of CFUs selected for the ***MGT*** curriculum in Tables. A and D1 must be equal to at least 15 CFU (**nota h**)

Curriculum ADVANCED ENERGY MANGEMENT

Table O2) - Mandatory curricular educational activities in the curriculum (30 CFU), TAF B

Course or Educational activity	Year/ Semester	CFU	SSD	TAF	Disciplinary area
Energetica (*) *Fundamentals of Energy Efficiency and Renewable Energy Technologies*	I / II	9	IIND-07/A (ex ING-IND/10)	B	Mechanical Engineering
Laboratorio di Ottimizzazione di Sistemi Termodinamici (*) *Laboratory of Thermodynamic Systems Optimization*	I / II	6	IIND-07/A (ex ING-IND/10)	B	Mechanical Engineering
Tecnologie Avanzate per l'Energia (*) *Advanced Energy Technologies*	II / I	6	IIND-07/A (ex ING-IND/10)	B	Mechanical Engineering
Misure Termofluidodinamiche *Thermo-Fluid-Dynamic Measurements*	II / II	9	IIND-07/A (ex ING-IND/10)	B	Mechanical Engineering

(*) Course valid for the ***MGT*** curriculum, too

Table B2) - Curricular educational activities of the student's choice (18 CFU), TAF B

Course or Educational activity	Year/ Semester	CFU	SSD	TAF	Disciplinary area
Sperimentazione e Impatto Ambientale delle Macchine (*) *Measurements and Environmental Impact of Machinery*	II / I	9	IIND-06/B (ex ING-IND/09)	B	Mechanical Engineering
Impianti di Generazione Termica *Heat Generation Plants*	I / I	9	IIND-06/B (ex ING-IND/09)	B	Mechanical Engineering
Impianti di Climatizzazione *Heating and Cooling systems*	II / II	9	IIND-07/A (ex ING-IND/10)	B	Mechanical Engineering
Termofluidodinamica Computazionale *Computational Thermal-Fluid-Dynamic*	II / II	9	IIND-07/A (ex ING-IND/10)	B	Mechanical Engineering

(*) Course valid for the ***MGT*** curriculum, too

Table D2) – Educational activities suggested for the student's autonomous choice (15 CFU), TAF D
Classes from TAF B <u>for SEI, GAE and SP curricula</u>, or classes from Tables A.TG, B.TG and C.TG, or:

Course or Educational activity	Year/ Semester	CFU	SSD	TAF	Disciplinary area / Mutations
Modellazione Geometrica per l'Energia e l'Ambiente *Geometrical Modelling for Energy and Environment*	I / II	9	IIND-03/B (ex ING-IND/15)	D	Specific for LM-IMEA
Plasmi e Fusione Termonucleare *Plasmas and Thermonuclear Fusion*	I / I	9	IIET-01/A (ex ING-IND/31)	D	LM-IELT
Sicurezza e Manutenzione degli Impianti Industriali *Safety and Maintenance of Industrial Plants*	I / II	9	IIND-05/A (ex ING-IND/17)	D	LM-IMPP
Tecnologie Speciali *Non-Conventional Manufacturing Technologies*	I / II	9	IIND-04/A (ex ING-IND/16)	D	LM-IMPP
Controlli Automatici *Automatic Controls*	I / II	9	IINF-04/A (ex ING-INF/04)	D	L-IINF
Energy Sustainability in Smart Transportation and Infrastructures *Sostenibilità Energetica nei Trasporti e nelle Infrastrutture Intelligenti*	I / II	9	IIND-07/A (ex ING-IND/10)	D	Specific for LM-IMEA
Mathematical Models and Computational Methods for Engineering Science *Modelli Matematici e Metodi Computazionali per l'Ingegneria*	I / I	9	MATH-04/A (ex MAT/07)	D	Specific for LM-IMEA
For the *MGT* curriculum: TAF D course (6 or 9 CFU) from Table C.TG (*)		6,9		D	

(*) The sum of CFUs selected for the ***MGT*** curriculum in Tables. A and D2 must be equal to at least 15 CFU (**nota h**)

Curriculum PROPULSION SYSTEMS

Table O3) - Mandatory curricular educational activities in the curriculum (24 CFU), TAF B

Course or Educational activity	Year/ Semester	CFU	SSD	TAF	Disciplinary area
Motori a Combustione Interna *Internal Combustion Engines*	I / I	9	IIND-06/A (ex ING-IND/08)	B	Mechanical Engineering
Sistemi di Propulsione Ibridi (*) *Hybrid Propulsion Systems*	I / II	6	IIND-06/A (ex ING-IND/08)	B	Mechanical Engineering
Oleodinamica e Pneumatica *Fluid Power and Pneumatic Systems*	II / II	9	IIND-06/A (ex ING-IND/08)	B	Mechanical Engineering

(*) Course valid for the ***MGT*** curriculum too

Table B3) - Curricular educational activities of the student's choice (18 CFU), TAF B

Course or Educational activity	Year/ Semester	CFU	SSD	TAF	Disciplinary area
Sperimentazione e Impatto Ambientale delle Macchine (*) *Measurements and Environmental Impact of Machinery*	II / I	9	IIND-06/B (ex ING-IND/09)	B	Mechanical Engineering
Acustica Applicata *Applied Acoustics*	II / I	9	IIND-07/A (ex ING-IND/10)	B	Mechanical Engineering
Progetto di Macchine *Fluid Machinery Design Principles*	II / II	9	IIND-06/A (ex ING-IND/08)	B	Mechanical Engineering
Termofluidodinamica Computazionale *Computational Thermal-Fluid-Dynamic*	II / II	9	IIND-07/A (ex ING-IND/10)	B	Mechanical Engineering

(*) Course valid for the ***MGT*** curriculum, too

Table C3) Curricular educational activities of the student's choice (6 CFU), TAF B

Course or Educational activity	Year/ Semester	CFU	SSD	TAF	Disciplinary area
Modellistica e Ottimizzazione di Sistemi di Propulsione *Modeling and Optimization of Power Units*	II / II	6	IIND-06/A (ex ING-IND/08)	B	Mechanical Engineering
Calibrazione e Controllo di Sistemi di Propulsione *Calibration and Control of Power Units*	II / II	6	IIND-06/A (ex ING-IND/08)	B	Mechanical Engineering

Table D3) – Educational activities suggested for the student's autonomous choice (15 CFU), TAF D
Classes from TAF B <u>for SEI, GAE and SP curricula</u>, or classes from Tables A.TG, B.TG and C.TG, or:

Course or Educational activity	Year/ Semester	CFU	SSD	TAF	Disciplinary area / Mutations
Modellazione Geometrica per l'Energia e l'Ambiente *Geometrical Modelling for Energy and Environment*	I / II	9	IIND-03/B (ex ING-IND/15)	D	Specific for LM-IMEA
Elettrotecnica per l'Automotive e la Meccatronica *Electrotechnics for Automotive and Mechatronics*	I / II	9	IIET-01/A (ex ING-IND/31)	D	Specific for LM-IMEA
Meccanica del Veicolo *Vehicle Dynamics*	I / II	9	IIND-02/A (ex ING-IND/13)	D	LM-IMPP
Tribologia e Diagnostica dei Sistemi Meccanici *Tribology and Diagnostic of Mechanical Systems*	I / I	9	IIND-02/A (ex ING-IND/13)	D	LM-IMPP
Costruzione di Autoveicoli *Automotive Design*	I / I	9	IIND-03/A (ex ING-IND/14)	D	LM-IMPP
Space Propulsion *Propulsione Spaziale*	I / II	9	IIND-01/G (ex ING-IND/07)	D	LM-IAER
Mathematical Models and Computational Methods for Engineering Science *Modelli Matematici e Metodi Computazionali per l'Ingegneria*	I / I	9	MATH-04/A (ex MAT/07)	D	Specific for LM-IMEA
For the *MGT* curriculum: TAF D course (6 or 9 CFU) from Table C.TG (*)		6,9		D	

(*) The sum of CFUs selected for the ***MGT*** curriculum in Tables. A and D3 must be equal to at least 15 CFU (**nota h**)

Curriculum SUSTAINABLE ENERGY

Table O4a) - Mandatory curricular educational activities in the curriculum (18 CFU), TAF B

Course or Educational activity	Year/ Semester	CFU	SSD	TAF	Disciplinary area
Heat Transfer Principles in Engineering *Fondamenti di Trasmissione del Calore per l'Ingegneria*	I / I	9	IIND-07/A (ex ING-IND/10)	B	Mechanical Engineering
Principles and Applications of Fluid Machinery *Principi e Applicazioni delle Macchine a Fluido*	I / II	9	IIND-06/A (ex ING-IND/08)	B	Mechanical Engineering

Table O4b) - Mandatory curricular educational activities in the curriculum (24 CFU), TAF B

Course or Educational activity	Year/ Semester	CFU	SSD	TAF	Disciplinary area
Advanced Energy Systems and Technologies *Sistemi e Tecnologie Energetiche Avanzate* Fundamentals *(Fondamenti)* Applications *(Applicazioni)*	 I / I I / II	 6 6	IIND-07/A (ex ING-IND/10)	B	Mechanical Engineering
Advanced Powertrains for a Sustainable Mobility *Sistemi di Propulsione Avanzati per la Mobilità Sostenibile* Fundamentals *(Fondamenti)* Modeling and Optimization (*Modellistica ed Ottimizzazione)*	 II / I II / II	 6 6	IIND-06/A (ex ING-IND/08)	B	Mechanical Engineering

Table B4) - Curricular educational activities of the student's choice (12 CFU), TAF B

Course or Educational activity	Year/ Semester	CFU	SSD	TAF	Disciplinary area
Fuel Cells for Power Generation and Energy Storage *Celle a Combustibile per la Produzione e lo Stoccaggio dell'Energia*	II / I	6	IIND-06/A (ex ING-IND/08)	B	Mechanical Engineering
Gas Turbines for Sustainable Power Production *Turbine a Gas per la Produzione Sostenibile di Energia*	II / I	6	IIND-06/A (ex ING-IND/08)	B	Mechanical Engineering
Low Carbon Boilers and Industrial Furnaces *Caldaie a bassa CO2 e Fornaci Industriali*	II / II	6	IIND-06/B (ex ING-IND/09)	B	Mechanical Engineering
Hydro, Wind and Ocean Energy Conversion Systems *Sistemi di Conversione dell'Energia Idroelettrica, Eolica e Marina*	II / II	6	IIND-06/A (ex ING-IND/08)	B	Mechanical Engineering
Fluid Power Systems for Energy Sustainability of Off-Road Vehicles *Sistemi Oleodinamici per la Sostenibilità Energetica di Veicoli Off-Road*	II / II	6	IIND-06/B (ex ING-IND/09)	B	Mechanical Engineering

Table C4) Curricular educational activities of the student's choice (12 CFU), TAF B

Course or Educational activity	Year/ Semester	CFU	SSD	TAF	Disciplinary area
Refrigeration and Heat Pump Technologies *Tecnologie per la Refrigerazione e Pompe di Calore*	II / I	6	IIND-07/A (ex ING-IND/10)	B	Mechanical Engineering
Thermo-economic Optimization of Complex Energy Systems *Ottimizzazione Termoeconomica di Sistemi Energetici Complessi*	II / II	6	IIND-07/A (ex ING-IND/10)	B	Mechanical Engineering
Lighting Technology and Acoustics *Illuminotecnica ed Acustica*	II / I	6	IIND-07/A (ex ING-IND/10)	B	Mechanical Engineering
Energy and Buildings *Energetica degli Edifici*	II / II	6	IIND-07/A (ex ING-IND/10)	B	Mechanical Engineering
Heating, Ventilation and Air Conditioning Systems *Sistemi di Riscaldamento, Ventilazione e Condizionamento d'Aria*	II / I	6	IIND-07/A (ex ING-IND/10)	B	Mechanical Engineering

Table D4) – Educational activities suggested for the student's autonomous choice (15 CFU), TAF D:

Course or Educational activity	Year/ Semester	CFU	SSD	TAF	Disciplinary area / Mutations
6 CFUs English courses from every didactic regulation table		6			
9 CFUs English courses from every didactic regulation table		6			
For the *MGT* curriculum: TAF D course (6 or 9 CFU) from Table C.TG (*)		6,9		D	

(*) The sum of CFUs selected for the ***MGT*** curriculum in Tables. A4 and D4 must be equal to at least 15 CFU (**nota h**)

Curriculum MINOR ET IN GREEN TECHNOLOGIES

Extra-curricular courses (at least 15 CFU in total, with at least 6 CFU from Table A.TG):

Course or Educational activity	Year/ Semester	CFU	SSD	TAF	
1 Course of at least 6 CFU from Table A.TG		6,9		C,D	Mandatory
Any ***MGT*** valid course		6,9		B,C,D	Mandatory
Courses and Seminaries from the Degree Course or the University		3		F	By choice

Table A.TG) – Educational activities specifically developed for the Minor

Course or Educational activity	Year/ Semester	CFU	SSD	TAF	Disciplinary area / Mutations
Industrial Ecology and Green Engineering *Ecologia Industriale e Ingegneria Verde*	I o II / II	6	ICHI-02/A (ex ING-IND/25)	C,D	Related/integrative Act LM-ICHI
Circular Bioeconomy for the ecological transition *Bioeconomia Circolare per la Transizione Ecologica*	I o II / II	6	CEAR-02/A (ex ICAR/03)	C,D	Related/integrative Act.LM-IAMT
Electrical Technologies for the Ecological Transition *Tecnologie elettriche per la transizione ecologica* Electric Energy Storage (*Accumulo di Energia Elettrica*) Electric Mobility and Generation from Renewables (*Mobilità Elettrica e Generazione da Fonti Rinnovabili*)	 I o II / II I o II / II	 2 4	IIET-01/A (ex ING-IND/31) IIND-08/A (ex ING-IND/32)	C,D	Related/integrative Act.LM-IELT
Sustainable Materials *Materiali Sostenibili*	I o II / II	6	IMAT-01/A (ex ING-IND/22)	C,D	Related/integrative Act.LM-IMAT
Thermo-Mechanical Technologies for the Energy Transition *Tecnologie Termo-Meccaniche per la Transizione Energetica*	II / II	6	IIND-07/A (ex ING-IND/10)	B	Mechanical Engineering

Table B.TG) – Educational activities changed from degree courses associated to the Minor

Course or Educational activity	Year/ Semester	CFU	SSD	TAF	Disciplinary area / Mutations
Environmental Chemical Engineering *Ingegneria Chimica Ambientale*	I o II / I	6	ICHI-02/A (ex ING-IND/25)	C,D	Related/integrative Act. LM-ICHI
Sustainable Technologies for Pollution Control *Tecnologie Sostenibili per il Controllo dell'Inquinamento Ambientale*	I o II / I	6	ICHI-02/A (ex ING-IND/25)	C,D	Related/integrative Act. LM-ICHI
Sustainable Process Design *Progettazione di Processi Sostenibili*	I o II / I	9	ICHI-02/A (ex ING-IND/25)	C,D	Related/integrative Act LM-ICHI
Impianti di Produzione da Fonti Tradizionali e Rinnovabili *Electric Power Plants Based on Traditional and Renewable Sources*	I o II / II	6	IIND-08/B (ex ING-IND/33)	C,D	Related/integrative Act. Specific for LM-IMEA
Energia dai Rifiuti ed Economia Circolare *Waste Energy and Circular Economy*	I o II / II	9	CEAR-02/A (ex ICAR/03)	C,D	Related/integrative Act. LM-IAMT
Ingegneria Sanitaria-Ambientale *Environmental Health Engineering*	I o II / II	6	CEAR-02/A (ex ICAR/03)	C,D	Related/integrative Act.LM-IAMT
Industrial Chemistry from Renewable Feedstocks *Chimica Industriale da Materie Prime Rinnovabili*	I o II / I	9	ICHI-02/B (ex ING-IND/27)	C,D	Related/integrative Act.LM-ICHI
Smart, Resilient and Sustainable City *Città Intelligente, Resiliente e Sostenibile*	I o II / I	9	CEAR-12/A (ex ICAR/20)	C,D	Related/integrative Act.LM-IAMT
Idraulica per l'Efficienza dei Sistemi Idrici *Hydraulics for Water Systems Efficiency* Efficienza dei sistemi idrici (*Water Systems Efficiency*) Resilienza dei sistemi idrici (*Water Systems Resilience*)	 I o II / I I o II / I	 6 3	CEAR-01/A (ex ICAR/01)	C,D	Related/integrative Act.LM-IAMT
Ingegneria dei Materiali Nanofasici per l'Energetica e la Sensoristica *Nanophasic Material Engineering for Energy and Sensors*	I o II / I	6	IMAT-01/A (ex ING-IND/22)	C,D	Related/integrative Act.LM-IMAT
Thermo-Chemical Conversion of Biomass and Waste *Conversione Termochimica di Biomasse e Rifiuti*	I o II / II	6	ICHI-01/C (ex ING-IND/26)	C,D	Related/integrative Act.LM-ICHI
Electric and Hybrid Vehicles *Veicoli Elettrici e Ibridi*	I o II / II	6	IIND-08/A (ex ING-IND/32)	C,D	Related/integrative Act.LM-IELT

Energy Management for Transportation *Gestione dell'Energia per i Trasporti*	I o II / I	9	IIND-08/A (ex ING-IND/32)	C,D	Related/integrative Act.LM-TEAM
Smart and Electric Mobility *Mobilità Intelligente ed Elettrica*	I o II / II	9	CEAR-03/B (ex ICAR/05)	C,D	Related/integrative Act. LM-IAMT
Impianti Idroelettrici *Hydroelectric Systems*	I o II / II	9	CEAR-01/B (ex ICAR/02)	C,D	Related/integrative Act.LM-IAMT
Materiali e Tecnologie per il Fotovoltaico *Materials and Technologies for Photovoltaic*	I o II / II	6	IMAT-01/A (ex ING-IND/22)	C,D	Related/integrative Act.LM-IMAT
Regenerative Chemistry *Chimica Rigenerativa*	I o II / I	6	CHEM-06/A (ex CHIM/07)	C,D	Related/integrative Act.LM-ICHI
Sistemi Energetici Innovativi *Innovative Energy Systems*	I o II / I	6	IIND-06/A (ex ING-IND/08)	B	Mechanical Engineering LM-IELT
Sperimentazione e Impatto Ambientale delle Macchine *Measurements and Environmental Impact of Machinery*	II / I	9	IIND-06/B (ex ING-IND/09)	B	Mechanical Engineering
Tecnologie Avanzate per l'Energia *Advanced Energy Technologies*	II / I	6	IIND-07/A (ex ING-IND/10)	B	Mechanical Engineering
Sistemi di Propulsione Ibridi *Automotive Power Units*	I / II	6	IIND-06/A (ex ING-IND/08)	B	Mechanical Engineering
Energetica *Fundamentals of Energy Efficiency and Renewable Energy Technologies*	I / II	9	IIND-07/A (ex ING-IND/10)	B	Mechanical Engineering
Laboratorio di Ottimizzazione di Sistemi Termodinamici *Laboratory of Thermodynamic Systems Optimization*	I / II	6	IIND-07/A (ex ING-IND/10)	B	Mechanical Engineering

Table C.TG) – Educational activities to promote digital skills pertinent to the Minor

Course or Educational activity	Year/ Semester	CFU	SSD	TAF	Disciplinary area / Mutations
Machine Learning and Big Data *Apprendimento Automatico e Big Data*	I o II / II	9	IINF-05/A (ex ING-INF/05)	D	LM-MOVE
Technologies for Information Systems *Tecnologie per i Sistemi Informativi*	I o II / II	9	IINF-05/A (ex ING-INF/05)	D	LM-IGES
Network Security *Sicurezza Informatica*	I o II / I	6	IINF-05/A (ex ING-INF/05)	D	LM-IINF

ANNEX 2.1

DEGREE PROGRAM DIDACTIC REGULATIONS

MECHANICAL ENGINEERING FOR THE ENERGY AND THE ENVIRONMENT

CLASS LM-33

School: Polytechnical and Basic Sciences

Department: Industrial Engineering

Didactic Regulations in force since the academic year 2025-2026

Course: ACUSTICA APPLICATA *APPLIED ACOUSTIC*	**Teaching Language:** ITALIAN
SSD (SUBJECT AREAS): IIND-07/A (EX ING-IND/10)	**CREDITS:** 9
Course year: I o II	**Type of Educational Activity: B**

Teaching Methods:
In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:
The group includes skills relating to the following topics: thermodynamic, thermokinetic analysis of energy processes and their environmental impact, principles, methodologies and technologies for sustainable energy conversion from renewable and conventional energy sources, final uses of energy, energy management, techniques for monitoring and processing energy data and models, energy efficiency technologies and applications, thermoeconomics, technologies for the energy transition, physics of the built environment, with particular reference to the interaction among occupants and the environment, thermophysics of buildings, technical plants for civil applications, energy diagnosis and optimization of the building-plant-territory system, applied acoustics, lighting engineering, air quality, passive systems and plant technologies for air conditioning and environmental well-being. It also studies thermo-fluid-dynamic phenomena in biological and agri-food systems, refrigeration technologies, thermotechnics, heat exchange and energy storage systems and components, fire safety, thermophysical properties of materials, measurements and thermo-fluid-dynamic controls, materials for energy, acoustics and lighting engineering.

Objectives:
The course aims to provide students with the fundamentals related to the wave equations and the main solutions, the analysis of acoustic signals and linear time invariant acoustic systems and knowledge on the perception of sounds and psychoacoustics. These will be useful in addressing problems of measurement and control of noise in closed and outdoor environments, in identifying and recognizing the main causes of noise (due to rotating machines, aero-acoustic sources or vibrating surfaces) and methods for containing noise through suitable sound-absorbing and sound-insulating systems. For this, during the course practical and numerical exercises of measurement of sound and design will be carried out by using commercial software. The course will highlight that the main objective is the psychoacoustic well-being which can be evaluated by using objective parameters deriving from measurement procedures, from numerical algorithms or through appropriate “sound virtualization” techniques, that is, the auralization techniques. Furthermore, the basic concepts of the sound quality of the noise / sound emitted by an industrial product will be introduced. All the above-mentioned issues will be contextualized within industrial realities through supplementary seminars held by companies and research centers.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:
Oral exam

Course: ADVANCED ENERGY SYSTEMS AND TECHNOLOGIES *SISTEMI E TECNOLOGIE ENERGETICHE AVANZATE* Mod. 1: FUNDAMENTALS *(FONDAMENTI)* Mod. 2: APPLICATIONS *(APPLICAZIONI)*	**Teaching Language:** ENGLISH
SSD (SUBJECT AREAS): IIND-07/A (EX ING-IND/10)	**CREDITS:** Mod. 1: 6 Mod. 2: 6
Course year: I	**Type of Educational Activity: B**

Teaching Methods:

In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:

Thermodynamic, thermoeconomic and environmental analysis of energy processes. Fundamentals of sustainable energy conversion. Energy efficiency in final uses. Renewable energy technologies. Energy management. Techniques for monitoring and processing energy data and models. Energy transition. Energy diagnosis.

Objectives:

The course will provide engineering and legislative methodologies to operate in the sectors of energy efficiency and renewable energy sources. Engineering, regulatory and economic-financial aspects will be addressed. The student will be able to identify, for each specific case, the possible technological solutions. The student will be also able to perform a comparison among these solutions, evaluating energy, environmental and economic aspects, developing a suitable preliminary technical-economic feasibility study. The course will also provide the knowledge required for the optimal management of advanced energy systems, based on the integration of renewable sources. The student will be also able to analyse novel and efficient solutions for the distribution and end uses of energy, including novel district heating and cooling networks and the technologies for sustainable mobility.

The course will also provide the basics of energy planning, designing the actions to be implemented to achieve the full decarbonisation of individual users or complex energy systems, such as smart energy networks and smart cities.

The following technical problems will be addressed: i) estimation of the energy demands of residential and industrial users; ii) techno-economic analysis and direct measurement of the performance of energy systems; iii) selection and analysis of the technologies for energy efficiency, renewable energy sources and for reduction of the environmental impact.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:

Numerical tests and oral exam

Course:	**Teaching Language:**
ADVANCED POWERTRAINS FOR A SUSTAINABLE MOBILITY *SISTEMI DI PROPULSIONE AVANZATI PER LA MOBILITÀ SOSTENIBILE* Mod. 1: FUNDAMENTALS *(FONDAMENTI)* Mod. 2: MODELING AND OPTIMIZATION (*MODELLISTICA ED OTTIMIZZAZIONE)*	ENGLISH

SSD (SUBJECT AREAS):	**CREDITS:**
IIND-06/A (ex ING-IND/08)	Mod. 1: 6 Mod. 1: 6

Course year: II	**Type of Educational Activity: B**

Teaching Methods:

In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:

The discipline covers the scientific and educational issues related to thermodynamic, fluid dynamic, [..] environmental and sustainability problems of all fluid machinery and fluid-based energy conversion systems. Of interest are the design, control, [..] optimization, operation, testing, [..] and environmental impact of fluid machinery and power systems (such as [..] internal combustion engines possibly integrated into hybrid propulsion systems, [..]), [..]. Likewise, devices involving chemical reactions [..] are issues of relevance. Further, the integration of those machineries and devices into more complex systems [..] as well as their usage for land, aerial and naval propulsion applications is of interest. [..].

Objectives:

The course will provide to the students the basic knowledge related to the operation of modern propulsion systems characterized by low environmental impact used for land, naval and transport sectors, also powered by alternative fuels and/or deriving from renewable energy sources. The main pollutant species generated by the propulsion system will be described, as well as the related formation and abatement methods. The configurations of hybrid electric propulsion system and the issues of the synergistic management of thermal and electric machines will be examined, too. Following the theoretical contents described above, the course will provide to the students the knowledge related to the thermo-fluid dynamic modelling using 0D, 1D and 3D CFD approaches of the modern propulsion systems. Emphasis will be devoted to the in-cylinder processes, to the gas exchange systems and to the fuel metering processes, with the aim to optimize their performance and limit the production of pollutant species. The modelling of the entire vehicle will be also covered, in order to predict and minimize the noxious emissions emitted by the propulsion system along homologation and real driving cycles.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:

Project discussion

Course: CALIBRATION AND CONTROL OF POWER UNITS *CALIBRAZIONE E CONTROLLO DI SISTEMI DI PROPULSIONE*	**Teaching Language:** ITALIAN
SSD (SUBJECT AREAS): IIND-06/A (ex ING-IND/08)	**CREDITS:** 6
Course year: II	**Type of Educational Activity: B**

Teaching Methods:
In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:
The discipline covers the scientific and educational issues related to thermodynamic, fluid dynamic, aero-acoustic, aero-mechanic, energetic, technological, environmental and sustainability problems of all fluid machinery and fluid-based energy conversion systems. Of interest are the design, control, diagnostic, optimization, operation, testing, commissioning and environmental impact of fluid machinery and power systems (such as turbines, expanders, internal combustion engines possibly integrated into hybrid propulsion systems, fluid power systems), as well as fans, compressors and pumps. Likewise, devices involving chemical reactions (such as combustors, gasifier, reactors, fuel cells and reverse electrolysis systems) and heat transfer (such as evaporators, condensers and recuperators) are issues of relevance. Further, the integration of those machineries and devices into more complex systems aimed at the generation, conversion, storage, and distribution of electrical and thermal energy, as well as their usage for land, aerial and naval propulsion applications is of interest. Finally, process engineering and service applications are also envisaged.

Objectives:
The course provides fundamental knowledge on the calibration and control methodologies of modern thermal and hybrid propulsion systems. In particular, the basics on control systems, calibration and control-oriented modeling of internal combustion engines, both spark ignition and compression, and hybrid propulsion systems are provided. The various phases of the calibration process are highlighted, illustrating both experimental and numerical techniques. Applications in the field of road, rail, naval and aeronautical transport will be presented. Furthermore, the effects of control strategies on fuel consumption, performance and polluting emissions of propulsion systems will be explored. Finally, energy optimization techniques for hybrid propulsion systems will be introduced. Additional seminars will be organized and held by staff from industry (Stellantis, Netcom, Teoresi, etc...), or from research centers (STEMS Institute of the CNR, ENEA).

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:
Oral

Course: CIRCULAR BIOECONOMY FOR THE ECOLOGICAL TRANSITION *BIOECONOMIA CIRCOLARE PER LA TRANSIZIONE ECOLOGICA*	**Teaching Language:** ENGLISH
SSD (SUBJECT AREAS): CEAR-02/A (EX ICAR/03)	**CREDITS:** 6
Course year: I or II	**Type of Educational Activity: C**

Teaching Methods:
In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:
The scientific-disciplinary contents involve engineering aspects in the protection of ecosystems equilibria, including studies on the biological cycles and ecological alterations.

Objectives:
The course aims to give the major insights on circular bioeconomy and ecological transition strategies to mitigate climate change and provide energy and food in a sustainable way. Also, the course aims to describe the main sources of greenhouse gases and the main anthropogenic implications on the natural, fundamental biogeochemical cycles of carbon, nitrogen and phosphorous.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:
The exam includes an oral test, and the discussion of a design project

Course: COMBUSTIONE *COMBUSTION*	**Teaching Language:** ITALIAN
SSD (SUBJECT AREAS): ICHI-02/A (EX ING-IND/25)	**CREDITS:** 9
Course year: I	**Type of Educational Activity: C**

Teaching Methods:
In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:
The scientific discipline includes the study of methodologies for the design, realization, verification and operation of industrial plants based on chemical-physical and biological transformations of matter aimed at the production of goods, the provision of services and the prevention or mitigation of modifications to the environment induced by human activities or settlements. Qualifying for the field, in both scientific and didactic-training activities, are: plant design including simulation, elaboration of quantified process and functional schemes including protection and control instrumentation; selection, design, prototyping and verification of reactors and equipment for unit operations and development of related experimental methodologies; safety and risk analysis of plants and processes; and economic, sustainability and environmental impact assessments also examined in the context of industrial ecology. Areas of focus are chemical, pharmaceutical, food, energy, extraction, refining, transport and storage technologies for raw materials and energy carriers; biotechnology; and technologies supporting environmental protection and the circular economy.

Objectives:
The course aims to provide the methodological tools and knowledge to frame combustion processes in the context of propulsion, sustainable mobility and power generation applications in order to evaluate their potential development under the constraints related to alternative fuels, pollutant emission limits and performance. Furthermore, the course defines the most relevant prototype configurations and equations describing combustion processes evolving under fixed boundary/initial conditions, analyzing their most significant parameters and most sensitive variations.
Finally, the course aims to provide the knowledge related to the mechanisms of formation of the major pollutants in combustion (VOC, PAH, nanoparticles, soot, NOx, dioxines, Particulate Matter) and the related reduction techniques.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:
Oral and discussion of a project work

Course: CONTROLLI AUTOMATICI *AUTOMATIC CONTROLS*	**Teaching Language:** ITALIAN
SSD (SUBJECT AREAS): IINF-04/A (EX ING-INF/04)	**CREDITS:** 9
Course year: I	**Type of Educational Activity: D**

Teaching Methods:
In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:

The scientific disciplinary area studies methods and technologies for information processing aimed at modeling, real-time automatic control, supervision, planning and management of plants, processes and dynamic systems in general. Such systems include, for example, industrial manufacturing processes, automation systems, operating machinery, robotic and mechatronic systems, mobility and transportation systems and networks, energy production and distribution systems, technologies and solutions for living environments, security, smart cities, avionics and automotive systems, and environmental, biological and biomedical, economic and social systems.

The Automatica approach enables the abstraction of dynamic structural properties from the particular application domain that can be represented by appropriate classes of mathematical models. This makes it possible to unify methods for analyzing complex dynamic systems-artificial and natural-and designing control and management systems in such a way as to endow them with forms of intelligence, learning, robustness, reliability, and autonomy that ensure, even without direct human intervention, optimized programmed behavior, adaptability, self-diagnosis of failures, and restoration of normal operating conditions.

Typical methodological tools concern: representation of systems, in the form of mathematical models from physical principles or data, for prediction of operation, simulation, performance optimization, diagnostics and control; analysis of structural properties of models such as stability, observability and controllability; identification and learning of models based on data; and design of planning and control systems suitable for ensuring that the process follows an assigned behavior.

The most relevant technological content covers devices and equipment for implementing control and automation on both the micro- and macro-scale, sensors and sensory data processing, actuation apparatus, embedded systems, human-machine interfaces, robotics (including mobile, collaborative and service) and mechatronics.

Key methodological and technological skills that relate to education include systems theory and automatic controls, modeling, identification, optimization, data acquisition and processing and machine learning techniques, robotics, and mechatronics.

Objectives:

The course aims to introduce students to the design of feedback control laws for dynamical systems and illustrate their possible applications. In particular, the main methodologies for the synthesis of linear control systems, both analog and digital, using both state feedback and output feedback, are explored. At the completion of the course the student will be able to design linear controllers, also with the help of software tools for the analysis, design, and simulation of control systems.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:
Written

Course: COSTRUZIONE DI AUTOVEICOLI *AUTOMOTIVE DESIGN*	**Teaching Language:** ITALIAN
SSD (SUBJECT AREAS): IIND-03/A (EX ING-IND/14)	**CREDITS:** 9
Course year: I	**Type of Educational Activity: D**

Teaching Methods:
In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:
The scientific activity of the disciplinary scientific area focuses on mechanical design, construction of mechanical machines and systems, including: elements, connections, structures, devices and interfaces. Theoretical and methodological, experimental and numerical knowledge is developed for the analysis of stresses and static and dynamic behavior of systems, structures, components and materials and for the evaluation of functionality and integrity in order to ensure safety, reliability, manufacturability, usability, maintainability and sustainability. Methodologies, applied at all dimensional scales with integration and aid of digital innovations, include theoretical and phenomenological modeling, numerical simulation, experimental and computational techniques, and functional and structural optimization. Instructional activities cover all phases of mechanical design: specification definition, feasibility analysis, conceptual and detailed design, structural analysis, prototyping, virtual and experimental validation, and product planning.

Objectives:
The aim of course is to provide tools and methods for the design of the main groups and systems of a motor vehicle. The practical exercises are aimed at showing design methodologies, also computer aided. It therefore falls within the design oriented subjects.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:
Project work and oral

Course: ECONOMIA ED ORGANIZZAZIONE AZIENDALE *ECONOMICS AND BUSINESS ORGANIZATION*	**Teaching Language:** ITALIAN
SSD (SUBJECT AREAS): IEGE-01/A (ex ING-IND/35)	**CREDITS:** 6
Course year: I	**Type of Educational Activity: C**

Teaching Methods:

In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:

The scientific-disciplinary sector focuses on developing and transferring the knowledge necessary to design and manage complex organizational systems within the framework of the intricate relationships between technology, economics, and management. The sector integrates engineering culture with the economics and management of businesses, organizations, and public and private institutions. The studies and main educational content pertain to processes of transformation, change, and innovation, i.e., the complex interactions between technological and social variables, aiming to understand their impacts on organizations and economic systems as well as strategic, managerial, and policy decisions. In studying these topics, the sector adopts modeling, design, and systemic approaches based on rigorous analytical methodologies.

Objectives:

The course aims to provide the fundamental concepts and analytical tools to model, describe and understand economic systems from the micro and macroeconomic perspectives.

From a microeconomic point of view, the course will cover the main models describing the behavior and decision-making mechanisms for allocating resources of individual economic actors, typically consumers and businesses. Furthermore, emphasis will be given to analyzing how these actors interact in a market economy and how equilibria are determined in terms of prices and demanded quantities.

From the macroeconomic perspective, the course will introduce the primary indicators used to describe national economic systems (e.g., gross domestic product, inflation, employment) and the methods used to determine the main macroeconomic variables.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:

Written and oral tests. The written test includes numerical exercises. The outcome of the written test is binding for the purposes of access to the oral test. If passed, the evaluations of the two tests will be weighted equally.

Course: ELECTRIC AND HYBRID VEHICLES *VEICOLI ELETTRICI E IBRIDI*	**Teaching Language:** ENGLISH
SSD (SUBJECT AREAS): IIND-08/A (EX ING-IND/32)	**CREDITS:** 6
Course year: I or II	**Type of Educational Activity: D**

Teaching Methods:
In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:
The scientific disciplinary field carries out scientific and educational-training activities in all areas that require skills to understand, conceive, design, control, validate and test apparatus and systems that generate, store, convert and use electrical energy. Included in this cultural domain are topics such as modeling, identification, simulation, design, control, diagnostics, prognostics and reliability, and testing of electromechanical, electrical, and power electronic apparatus and systems, including digital systems and sensor technology, that use, generate, transmit, or store electrical energy. Technologies for the use and management of electrical energy in all application areas are included. In addition, issues of electromagnetic compatibility, between electrical and electronic components and between them and the environment are studied. Methodologies and tools used include the use of physical-mathematical and circuit models, numerical, symbolic and finite element simulation, experimental validation, data analysis, digital technologies, artificial intelligence, embedded control and Power-Hardware-In-the-Loop.

Objectives:
The goal is to make the student able to set up and solve design and control problems of an electric or hybrid powertrain and the energetic management of on-board sources.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:
Oral

Course:
ELECTRICAL TECHNOLOGIES FOR THE ECOLOGICAL TRANSITION
TECNOLOGIE ELETTRICHE PER LA TRANSIZIONE ECOLOGICA
Mod. 1: ELECTRIC ENERGY STORAGE (*ACCUMULO DI ENERGIA ELETTRICA*)
Mod. 2: ELECTRIC MOBILITY AND GENERATION FROM RENEWABLES (*MOBILITÀ ELETTRICA E GENERAZIONE DA FONTI RINNOVABILI*)

Teaching Language:
ENGLISH

SSD (SUBJECT AREAS):
Mod. 1: IIET-01/A (EX ING-IND/31)
Mod. 2: IIND-08/A (EX ING-IND/32)

CREDITS:
Mod. 1: 2
Mod. 2: 4

Course year: I

Type of Educational Activity: C

Teaching Methods:
In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:
From Declaration of SSD IIET-01/A (EX ING-IND/31): The scientific disciplinary field studies the theoretical and experimental aspects and the development of related applications of the two complementary research strands of electromagnetic fields and electric and electronic circuits in civil, industrial and information engineering. In the first strand, problems of electromagnetic field, electromagnetic compatibility, magnetofluid dynamics, and modeling and diagnostics of materials of electrical and magnetic interest are studied. In the second strand, circuits, both analog and digital, and related models are studied: linear, nonlinear and time-varying, concentrated and distributed parameter, signal and power, one- and multidimensional. The two complementary approaches are applied to the analysis, synthesis, numerical modeling and automatic design of electrical equipment, devices and systems, plasma engineering, thermonuclear fusion, particle accelerators, electrothermia, electromagnetic compatibility, quality, safety and environmental impact in electrical applications, signal processing circuits, adaptive circuits and neural networks, power electronics and electrical energy conversion. Teaching skills range from the fundamentals of Electrical Engineering to research and application topics in the field.
From Declaration of SSD IIND-08/A (EX ING-IND/32): The scientific disciplinary field carries out scientific and educational-training activities in all areas that require skills to understand, conceive, design, control, validate and test apparatus and systems that generate, store, convert and use electrical energy. Included in this cultural domain are topics such as modeling, identification, simulation, design, control, diagnostics, prognostics and reliability, and testing of electromechanical, electrical, and power electronic apparatus and systems, including digital systems and sensor technology, that use, generate, transmit, or store electrical energy. Technologies for the use and management of electrical energy in all application areas are included. In addition, issues of electromagnetic compatibility, between electrical and electronic components and between them and the environment are studied. Methodologies and tools used include the use of physical-mathematical and circuit models, numerical, symbolic and finite element simulation, experimental validation, data analysis, digital technologies, artificial intelligence, embedded control and Power-Hardware-In-the-Loop.

Objectives:
Addressed to Master's Degree Courses in Electrical and Non-Electrical Engineering, the course aims to present the characterizing aspects of electric mobility and the generation of electricity from renewable sources. The course also aims to discuss with students the benefits of these green technologies towards the ecological transition, together with the problems they can introduce. Particular attention is paid to the central role played by the different electrical energy storage systems in the areas covered.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:
Oral

Course: ELETTROTECNICA PER L'AUTOMOTIVE E LA MECCATRONICA *ELECTROTECHNICS FOR AUTOMOTIVE AND MECHATRONICS*	**Teaching Language:** ITALIAN
SSD (SUBJECT AREAS): IIET-01/A (EX ING-IND/31)	**CREDITS:** 9
Course year: I	**Type of Educational Activity: D**

Teaching Methods:

In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:

The scientific disciplinary field studies the theoretical and experimental aspects and the development of related applications of the two complementary research strands of electromagnetic fields and electric and electronic circuits in civil, industrial and information engineering. In the first strand, problems of electromagnetic field, electromagnetic compatibility, magnetofluid dynamics, and modeling and diagnostics of materials of electrical and magnetic interest are studied. In the second strand, circuits, both analog and digital, and related models are studied: linear, nonlinear and time-varying, concentrated and distributed parameter, signal and power, one- and multidimensional. The two complementary approaches are applied to the analysis, synthesis, numerical modeling and automatic design of electrical equipment, devices and systems, plasma engineering, thermonuclear fusion, particle accelerators, electrothermia, electromagnetic compatibility, quality, safety and environmental impact in electrical applications, signal processing circuits, adaptive circuits and neural networks, power electronics and electrical energy conversion. Teaching skills range from the fundamentals of Electrical Engineering to research and application topics in the field.

Objectives:

The course illustrates the main applications of electrical engineering in the mechatronic and automotive fields. Special reference will be made to the production and storage mechanisms of electrical energy relevant to automotive applications and to the treatment of non-linear circuits used in mechatronics, also by means of numerical simulations and laboratory experiences.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:

Oral

Course:	**Teaching Language:**
ENERGETICA *FUNDAMENTALS OF ENERGY EFFICIENCY AND RENEWABLE ENERGY TECHNOLOGIES*	ITALIAN

SSD (SUBJECT AREAS):	**CREDITS:**
IIND-07/A (EX ING-IND/10)	9

Course year: I	**Type of Educational Activity: B**

Teaching Methods:

In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:

The group includes skills relating to the following topics: thermodynamic, thermokinetic analysis of energy processes and their environmental impact, principles, methodologies and technologies for sustainable energy conversion from renewable and conventional energy sources, final uses of energy, energy management, techniques for monitoring and processing energy data and models, energy efficiency technologies and applications, thermoeconomics, technologies for the energy transition, physics of the built environment, with particular reference to the interaction among occupants and the environment, thermophysics of buildings, technical plants for civil applications, energy diagnosis and optimization of the building-plant-territory system, applied acoustics, lighting engineering, air quality, passive systems and plant technologies for air conditioning and environmental well-being. It also studies thermo-fluid-dynamic phenomena in biological and agri-food systems, refrigeration technologies, thermotechnics, heat exchange and energy storage systems and components, fire safety, thermophysical properties of materials, measurements and thermo-fluid-dynamic controls, materials for energy, acoustics and lighting engineering.

Objectives:

The course aims to provide students with the advanced knowledge and specialist skills necessary to face and solve the technical-engineering problems characteristic of the energy management sector, with reference to technologies and solutions for rational and eco-friendly use of both conventional and renewable energy resources.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:

Written and oral

Course: ENERGIA DAI RIFIUTI ED ECONOMIA CIRCOLARE *WASTE ENERGY AND CIRCULAR ECONOMY*	**Teaching Language:** ITALIAN
SSD (SUBJECT AREAS): CEAR-02/A (EX ICAR/03)	**CREDITS:** 9
Course year: I or II	**Type of Educational Activity: C, D**

Teaching Methods:
In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:
Scientific-disciplinary contents invest engineering aspects in environmental protection, chemical, physical and biological pollution prevention, ecological transition, circular and sustainable recovery and use of matter, water and energy. They include studies and models on: biogeochemical cycles, ecological and climatic alterations, pollutant dynamics in porous solids, liquids and aeriform bodies, ecotoxicology, health and environmental impacts and risks. They apply to industrial technologies, development of strategies, plans and projects for monitoring, protection and remediation of environmental compartments; design, construction, operation, impact assessment of water treatment and drinking water infrastructure, purification, remediation, disposal and recovery of wastes, liquid discharges, sludge, groundwater, gaseous effluents, soils and sediments. They use theoretical and experimental approaches to analyze pollutant transport processes and mechanisms and include the development of methods and indicators to support impact assessments, life-cycle analysis, circularity and sustainability, and environmental certification and permitting.

Objectives:
To provide the knowledge of the principles of the circular economy and the techniques of energy and/or material recovery from waste, together with the knowledge of the elements necessary for the choice, design and implementation of waste treatment systems.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:
The exam consists in a written exam, an oral exam, and in a discussion of a project work

Course: ENERGY AND BUILDINGS *ENERGETICA DEGLI EDIFICI*	**Teaching Language:** ENGLISH
SSD (SUBJECT AREAS): IIND-07/A (EX ING-IND/10)	**CREDITS:** 6
Course year: II	**Type of Educational Activity: B**

Teaching Methods:
In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:
Applied thermodynamics; heat transfer; thermofluid-dynamics; thermodynamic analysis of energy processes and their environmental impact; principles of sustainable conversion and final use of energy from renewable and non-renewable energy sources; thermophysics of buildings; energy management; energy diagnosis and optimization of the building-plant-territory system; monitoring techniques; development of energy models, energy efficiency; heating and cooling systems; systems and components for the heat exchange; energy storage; thermophysical properties of materials; passive systems for air conditioning and environmental well-being.

Objectives:
At the end of the course, the student will have acquired knowledge relating to the sustainable design of buildings. The goals of the course are to: teach the fundamental principles of sustainable building design, concerning the complex "Building-Plant-Renewable Sources" system, according to international directives and guidelines for the decarbonization of the sector, presenting the new frontiers of energy design and requalification, the standards of nearly and net zero-energy buildings, plus-energy houses, green buildings, zero-emission buildings; understand and select the environmental comfort models; develop the capability of designing the energy efficiency measures for the opaque and transparent envelope of buildings, also by integrating passive solar systems and bioclimatic technologies; proceed with energy performance evaluations, using international indicators, applying tools and methods for energy analysis, according to semi-stationary and hourly dynamic methods; understand the impact on the energy balance of each energy use; explore the potential for the on-site conversion from renewable sources; develop models for certifying energy performance (EPC) of buildings.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:
Oral exam with discussion of a project

Course:	**Teaching Language:**
ENERGY SUSTAINABILITY IN SMART TRANSPORTATION AND INFRASTRUCTURES *SOSTENIBILITÀ ENERGETICA NEI TRASPORTI E NELLE INFRASTRUTTURE INTELLIGENTI*	ENGLISH
SSD (SUBJECT AREAS): IIND-07/A (EX ING-IND/10)	**CREDITS:** 9
Course year: I or II	**Type of Educational Activity: D**

Teaching Methods:

In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:

In general, the academic scientific disciplinary sector studies fundamentals and applicative topics of applied physics, applied thermodynamics, applied thermo-fluid-dynamics and heat transfer. Here, the following skills are included: thermodynamic analysis of energy processes and their environmental impact, energetics, conversion and use of energy, energy sources and skills, energy management, renewable energies, thermo-economics, heat transfer and applied thermo-fluid-dynamics, thermotechnics, HVAC systems, and refrigeration technologies, thermo-technical systems and thermal equipment, thermophysical properties of materials, and thermo-fluid-dynamics measurements.

Objectives:

The course can be chosen both at the I and II year. The course aims at training a new generation of engineers interested in operating in the fields of energy, economic and environmental sustainability of modern transportation systems such as large ships, trains, airplanes, and electric vehicles (with particular attention to the concepts of Vehicle to Building - V2B and Vehicle to Grid - V2G), and the related infrastructures (ports, railway/metro stations, airports, highways, etc.) to be conceived and designed as modern energy hubs. Students will develop skills on: 1) energy-saving and low pollutant emission solutions based on innovative plant technologies, new construction materials, and renewable energy sources; 2) developing innovative methodologies and control strategies to minimize energy consumption by also taking into consideration current boundary conditions (operating and weather conditions, etc.), availability of renewable energy sources and economic issues; 3) innovative approaches to design and manage the aforementioned systems for also guaranteeing the hygro-thermal comfort of occupants and the air quality of indoor spaces. The target will be achieved through the theoretical learning of both the best practices and the most advanced strategies for energy saving of transportation vehicles/facilities, through the development of critical thinking to determine feasible solutions, as well as through advanced modelling and simulation techniques to assess and optimize the energy, economic and environmental performance of the considered systems. Specifically, the design of the envelope-plant system (buildings, infrastructures, transportation systems, renewable energy plants, etc.) and the related considered operating parameters will be carried out with a BIM (Building Information Modelling) to BEM (Building Energy Modelling) approach and the implementation of multi-objective optimization procedures. This aim will be also obtained by using specific professional computer tools, such as Autodesk Revit, OpenStudio, EnergyPlus, TRNSYS, MATLAB/Simulink, etc.. Finally, specific design case studies will be developed for new and existing systems (to be energy refurbished and revamped).

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:

The grade is achieved on the base of the quality of the design project and the answers provided during the oral exam. The final grade is carefully motivated to the student.

Course: FLUID POWER SYSTEMS FOR ENERGY SUSTAINABILITY OF OFF-ROAD VEHICLES *SISTEMI OLEODINAMICI PER LA SOSTENIBILITÀ ENERGETICA DI VEICOLI OFF-ROAD*	**Teaching Language:** ENGLISH
SSD (Subject Areas): IIND-06/B	**CREDITS:** 6
Course year: II	**Type of Educational Activity:** B

Teaching Methods:

in person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:

The discipline covers the energy conversion systems from conventional sources (fossil fuels and nuclear reactor fuels) and renewable ones (solar, wind, hydro and tidal, geothermal, from biomass and solid wastes). Of interest are the production and usage of alternative fuels, driving systems, thermal plants, heat and refrigeration pumps, as well as the fluid-based energy systems, the energy transportation process, the energy recovery and storage systems, and their role inside smart grids. Likewise, fluid power components and devices finalized at direct energy conversion process are of relevance. The scientific and educational aspects of the above-mentioned energy systems and of the related machineries deal with thermodynamic, fluid-dynamic, technology, safety, diagnostic and control issues, with a particular focus on the environmental impact and on the technologies specifically designed for their mitigation or abatement. Those aspects are analyzed in an energy planning context at several scales not disregarding the sustainability of the various process, systems and components within their life cycle.

Objectives:

The course aims to provide the skills to select and optimize from the energy standpoint (loss reduction, etc.) components of a fluid power system for off-road mobility (diggers, tractors, etc.). It also aims to provide the knowledges to design a complete system for off-road with a special care for energy sustainability aspects.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:

The exam consists of a project related to a complex application. Passing this test determines access to an oral interview inherent in both the discussion of the project and the answer to theoretical questions.

Course: FUEL CELLS FOR POWER GENERATION AND ENERGY STORAGE *CELLE A COMBUSTIBILE PER LA PRODUZIONE E LO STOCCAGGIO DELL'ENERGIA*	**Teaching Language:** ENGLISH
SSD (SUBJECT AREAS): IIND-06/A (ex ING-IND/08)	**CREDITS:** 6
Course year: II	**Type of Educational Activity: B**

Teaching Methods:

In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:

The discipline covers the scientific and educational issues related to thermodynamic, fluid dynamic, [..], energetic, [..] environmental and sustainability problems of all fluid machinery and fluid-based energy conversion systems. Of interest are the design, control, diagnostic, optimization, operation, testing, [..] and environmental impact of fluid machinery and power systems [..], as well as fans, compressors and pumps. Likewise, devices involving chemical reactions (such as [..] fuel cells and reverse electrolysis systems) and heat transfer [..] are issues of relevance. Further, the integration of those machineries and devices into more complex systems aimed at the generation, conversion, storage, and distribution of electrical and thermal energy, as well as their usage for land, aerial and naval propulsion applications is of interest [..].

Objectives:

The course will provide the fundamentals of the thermodynamic and physicochemical processes that occur within fuel cells. The differences between fuel cells according to the type of fuel used, the membrane and the electrolyte will be explained, highlighting, for each type of cell, the fields of application, the criteria of choice, the advantages and disadvantages. A number of operating schemes in the different fields of application will also be illustrated as examples, highlighting the ways in which the energy produced (electrical and thermal) can be exploited, also illustrating the use of the cell reactor in regenerative mode, with the aim of producing synthetic fuels. Storage, transportation and safety issues arising from the use of hydrogen and other alternative fuels will be presented.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:

Oral

Course: GAS TURBINES FOR SUSTAINABLE POWER PRODUCTION *TURBINE A GAS PER LA PRODUZIONE SOSTENIBILE DI ENERGIA*	**Teaching Language:** ENGLISH
SSD (SUBJECT AREAS): IIND-06/A (ex ING-IND/08)	**CREDITS:** 6
Course year: II	**Type of Educational Activity: B**

Teaching Methods:
In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:
The discipline covers the scientific and educational issues related to thermodynamic, fluid dynamic, aero-acoustic, aero-mechanic, energetic, technological, environmental and sustainability problems of all fluid machinery and fluid-based energy conversion systems. Of interest are the design, control, diagnostic, optimization, operation, testing, commissioning and environmental impact of fluid machinery and power systems (such as turbines, expanders, internal combustion engines possibly integrated into hybrid propulsion systems, fluid power systems), as well as fans, compressors and pumps. Likewise, devices involving chemical reactions (such as combustors, gasifier, reactors, fuel cells and reverse electrolysis systems) and heat transfer (such as evaporators, condensers and recuperators) are issues of relevance. Further, the integration of those machineries and devices into more complex systems aimed at the generation, conversion, storage, and distribution of electrical and thermal energy, as well as their usage for land, aerial and naval propulsion applications is of interest. Finally, process engineering and service applications are also envisaged.

Objectives:
The course deals with the energy, environmental, thermo-fluid dynamics and technological problems of gas turbines, and their use in various plant configurations and aeronautical propulsion applications. The types of hybrid systems based on gas turbine with ORC system, fuel cells or solar field are studied, with particular attention to systems with renewable energy. New generation plants with high performance and innovative fuels, such as biomass synthesis gases and hydrogen mixtures, with particular attention to the environmental impact are addressed.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:
Oral

Course: GESTIONE AZIENDALE *BUSINESS MANAGEMENT* Mod. 1: GESTIONE AZIENDALE *(BUSINESS MANAGEMENT)* Mod. 2: *LABORATORIO DI GESTIONE AZIENDALE (BUSINESS MANAGEMENT LAB)*	**Teaching Language:** ITALIAN
SSD (SUBJECT AREAS): IEGE-01/A (ex ING-IND/35)	**CREDITS:** Mod. 1: 6 Mod. 2: 3
Course year: I	**Type of Educational Activity: C**

Teaching Methods:
In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:
The scientific-disciplinary sector focuses on developing and transferring the knowledge necessary to design and manage complex organizational systems within the framework of the intricate relationships between technology, economics, and management. The sector integrates engineering culture with the economics and management of businesses, organizations, and public and private institutions. The studies and main educational content pertain to processes of transformation, change, and innovation, i.e., the complex interactions between technological and social variables, aiming to understand their impacts on organizations and economic systems as well as strategic, managerial, and policy decisions. In studying these topics, the sector adopts modeling, design, and systemic approaches based on rigorous analytical methodologies.

Objectives:
The course aims to provide the knowledge and tools necessary for the study, evaluation, and analysis of the internal and external environment of the enterprise. During the course, the behavior of economic actors within the context in which they operate will be examined, providing the foundations and tools to evaluate and suggest appropriate organizational strategies and configurations. The course will cover both the internal and external environment of the company.
Furthermore, basic notions for the analysis of costs and business performance will be provided, enabling students to analyze and advise on the most appropriate strategic and structural approaches for economic actors, in relation to the specific context. Students will acquire skills to analyze and evaluate the economic results of business activities. The course aims to develop knowledge of the principles of financial statement preparation (balance sheet and income statement) and to promote the use of the main financial analysis indicators. Additionally, it will provide skills for cash flow analysis and offer a comprehensive understanding of the various dimensions of corporate sustainability and reporting methods.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:
Written and oral tests and project work (optional)

Course: GESTIONE DI SISTEMI TERMODINAMICI AVANZATI *MANAGEMENT OF ADVANCED THERMODYNAMIC SYSTEMS*	**Teaching Language:** ITALIAN
SSD (SUBJECT AREAS): IIND-07/A (EX ING-IND/10)	**CREDITS:** 6
Course year: II	**Type of Educational Activity: B**

Teaching Methods:
In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:
The group includes skills relating to the following topics: thermodynamic, thermokinetic analysis of energy processes and their environmental impact, principles, methodologies and technologies for sustainable energy conversion from renewable and conventional energy sources, final uses of energy, energy management, techniques for monitoring and processing energy data and models, energy efficiency technologies and applications, thermoeconomics, technologies for the energy transition, physics of the built environment, with particular reference to the interaction among occupants and the environment, thermophysics of buildings, technical plants for civil applications, energy diagnosis and optimization of the building-plant-territory system, applied acoustics, lighting engineering, air quality, passive systems and plant technologies for air conditioning and environmental well-being. It also studies thermo-fluid-dynamic phenomena in biological and agri-food systems, refrigeration technologies, thermotechnics, heat exchange and energy storage systems and components, fire safety, thermophysical properties of materials, measurements and thermo-fluid-dynamic controls, materials for energy, acoustics and lighting engineering.

Objectives:
The objective is to provide to the student tools to analyze working data about components and machines that produce and/or transform energy, as well as users' consumption data, in order to define parameters and build-up useful information to assess performances, based on thermo-economics analysis, and evaluate faults.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:
Oral and project discussion

Course: HEAT TRANSFER PRINCIPLES IN ENGINEERING *FONDAMENTI DI TRASMISSIONE DEL CALORE PER L'INGEGNERIA*	**Teaching Language:** ENGLISH
SSD (SUBJECT AREAS): IIND-07/A (EX ING-IND/10)	**CREDITS:** 9
Course year: I	**Type of Educational Activity: B**
Teaching Methods: In person	
Contents extracted from the SSD declaratory consistent with the training objectives of the course: Fundamental and applicative aspects of applied thermodynamics, applied thermofluid-dynamics and heat transfer. Thermodynamic analysis of energy processes and their environmental impact, conversion and use of energy, thermotechnics, thermophysical properties of materials, thermofluiddynamic measurements and controls.	
Objectives: At the end of the course, the student will have acquired knowledge relating to the fundamental principles and methods of heat transfer. The goals of the course are to: teach the fundamental principles and laws of heat transfer and to apply these principles to the resolution of practical problems; to formulate the models necessary to study, analyze and design heat exchange equipment; to develop the ability to solve heat transfer problems by making use of methods specific to a broad-spectrum technical training and fundamental tools for the development of a study also based on the aid of numerical models (finite volumes, finite differences, finite elements).	
Propaedeuticities: **Is a propaedeuticity for:**	
Types of examinations and other tests: Written and Oral exam with discussion of a project	

Course:	**Teaching Language:**
HEATING, VENTILATION AND AIR CONDITIONING SYSTEMS *SISTEMI DI RISCALDAMENTO, VENTILAZIONE E CONDIZIONAMENTO DELL'ARIA*	ENGLISH
SSD (SUBJECT AREAS): IIND-07/A (EX ING-IND/10)	**CREDITS:** 6
Course year: II	**Type of Educational Activity: B**

Teaching Methods:

In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:

Physics of the built environment, with special reference to the interaction among occupants and the environment; thermophysics of buildings; technical plants for civil applications; energy diagnosis and optimization of the building-plant-territory system; air quality; passive systems and plant technologies for air conditioning and environmental well-being; refrigeration technologies; thermotechnics.

Objectives:

The course aims to develop knowledge on the energy-efficient design of HVAC (Heating, Ventilation and Air Conditioning) systems (for building, ship, train, car, bus, aircraft) with a focus on economic and environmental sustainability. It provides insights into control systems, highlighting their technical and practical aspects with particular attention to energy efficiency. By the end of the course, the student will be able to: 1) choose the best HVAC system based on the use of the spaces, the hygrothermal comfort/air quality to be ensured, and energy and economic considerations; 2) design and regulate the various components of the system (heating-cooling plant and substations, working fluid distribution networks, air handling units, heat exchange units, control system) using specific software, including a BIM (Building Information Modelling) approach.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:

The examination takes place through an oral interview aimed at verifying the understanding of theoretical principles and analysis and synthesis methodologies presented during the lessons. The assessment will take into account the results of a possible written test and the design work.

Course: HYDRO, WIND AND OCEAN ENERGY CONVERSION SYSTEMS *SISTEMI DI CONVERSIONE DELL'ENERGIA IDROELETTRICA, EOLICA E MARINA*	**Teaching Language:** ENGLISH
SSD (Subject Areas): IIND-06/A	**CREDITS:** 6
Course year: II	**Type of Educational Activity:** B

Teaching Methods:
in person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:
The discipline covers the scientific and educational issues related to […] fluid dynamic […] problems of all fluid machinery and fluid-based energy conversion systems. Of interest are the design, control, […] optimization, operation, testing […] of fluid machinery and power systems (such as turbines […]) […]. Further, the integration of those machineries and devices into more complex systems aimed at the generation, conversion, storage […] of electrical […] energy […] is of interest […].

Objectives:
The course covers the most relevant aspects of hydro, wind and ocean energy systems in terms of performance analysis and design. The emphasis is on the operation, selection and sizing of hydraulic and wind turbines.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:
Written or oral

Course:	**Teaching Language:**
IDRAULICA PER L'EFFICIENZA DEI SISTEMI IDRICI *HYDRAULICS FOR WATER SYSTEMS EFFICIENCY* Mod. 1: EFFICIENZA DEI SISTEMI IDRICI (*WATER SYSTEMS EFFICIENCY*) Mod. 2: RESILIENZA DEI SISTEMI IDRICI (*WATER SYSTEMS RESILIENCE*)	ITALIAN

SSD (SUBJECT AREAS):	**CREDITS:**
CEAR-01/A (EX ICAR/01)	Mod. 1: 6 Mod. 2: 3

Course year: I or II	**Type of Educational Activity: C, D**

Teaching Methods:

In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:

The scientific disciplinary field develops the topics of fluid mechanics and its applications in engineering and studies the laws of fluid motion and associated transport processes using a theoretical, computational and experimental approach through physical models and field measurements. Application domains include: natural water bodies (rivers, lakes, sea, groundwater) and the atmosphere and their interaction with the natural and built environment (e.g. river, coastal, maritime and transitional zone engineering, ecohydraulics, urban and environmental fluid mechanics); fluid adduction distribution and drainage systems; hydraulic devices and machines in civil and industrial settings and energy production and storage systems, particularly hydroelectric and from the sea; multiphysics processes in interdisciplinary areas (e.g., biological and multiphase fluids, fluid-structure interaction, fluid-acoustics, pollutant dispersion). The topics are addressed by integrating scientific knowledge, technologies, and designs with socioeconomic implications and the needs for risk mitigation, environmental protection, and climate change resilience.

Objectives:

Acquisition of knowledge on the problems of hydraulics related to the use of energy in complex water systems: pressurized water networks, unsteady state conditions, hydraulic machines, modern measuring and control equipment, performance tests, numerical methods used in the design and control of water networks.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:

Oral and project discussion

Course: IMPIANTI CON TURBINA A GAS *GAS TURBINE BASED POWER PLANTS*	**Teaching Language:** ITALIAN
SSD (SUBJECT AREAS): IIND-06/A (EX ING-IND/08)	**CREDITS:** 9
Course year: II	**Type of Educational Activity: B**

Teaching Methods:
In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:
The discipline covers the scientific and educational issues related to thermodynamic, fluid dynamic, aero-acoustic, aero-mechanic, energetic, technological, environmental and sustainability problems of all fluid machinery and fluid-based energy conversion systems. Of interest are the design, control, diagnostic, optimization, operation, testing, commissioning and environmental impact of fluid machinery and power systems (such as turbines, expanders, internal combustion engines possibly integrated into hybrid propulsion systems, fluid power systems), as well as fans, compressors and pumps. Likewise, devices involving chemical reactions (such as combustors, gasifier, reactors, fuel cells and reverse electrolysis systems) and heat transfer (such as evaporators, condensers and recuperators) are issues of relevance. Further, the integration of those machineries and devices into more complex systems aimed at the generation, conversion, storage, and distribution of electrical and thermal energy, as well as their usage for land, aerial and naval propulsion applications is of interest. Finally, process engineering and service applications are also envisaged.

Objectives:
The course aims to deepen the study of the new generation gas turbine systems, also integrated with a renewable energy system for a low environmental impact. The study of both conventional and hybrid aircraft engines will be tackled. With reference to electricity production systems, the most recent methodologies available for the reduction of consumption and polluting emissions, as well as carbon dioxide, will be studied in detail. To this end, the study of innovative combustion systems (DLN combustors, LPP, RQL) will be addressed and their impact on the production of polluting emissions, in particular NOx, will be quantified. The study of innovative fuels derived from biomass or from steam reforming and from mixtures with hydrogen will be addressed. The gas turbine plant will be examined in cogeneration and integrated with a solar field and / or ORC (Organic Rankine Cycle) systems. The study of gas/steam mixed cycles (STIG, HAT, RWI) and combined cycles will be addressed.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:
Oral / Project discussion

Course:	**Teaching Language:**
IMPIANTI DI CLIMATIZZAZIONE *HEATING AND COOLING SYSTEMS*	ITALIAN

SSD (SUBJECT AREAS):	**CREDITS:**
IIND-07/A (EX ING-IND/10)	9

Course year: I or II	**Type of Educational Activity: B**

Teaching Methods:

In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:

The group includes skills relating to the following topics: thermodynamic, thermokinetic analysis of energy processes and their environmental impact, principles, methodologies and technologies for sustainable energy conversion from renewable and conventional energy sources, final uses of energy, energy management, techniques for monitoring and processing energy data and models, energy efficiency technologies and applications, thermoeconomics, technologies for the energy transition, physics of the built environment, with particular reference to the interaction among occupants and the environment, thermophysics of buildings, technical plants for civil applications, energy diagnosis and optimization of the building-plant-territory system, applied acoustics, lighting engineering, air quality, passive systems and plant technologies for air conditioning and environmental well-being. It also studies thermo-fluid-dynamic phenomena in biological and agri-food systems, refrigeration technologies, thermotechnics, heat exchange and energy storage systems and components, fire safety, thermophysical properties of materials, measurements and thermo-fluid-dynamic controls, materials for energy, acoustics and lighting engineering.

Objectives:

The course can be chosen in both the first and second years. The course aims to develop knowledge on the energetically efficient design of the system encompassing structure and equipment (building, ship, train, vehicle, aircraft), also with a view towards economic and environmental sustainability. It provides insights into the thermophysics of the structure and air conditioning systems, highlighting their technical and applicative aspects with particular attention to energy efficiency. By the end of the course, the student will be able to: 1) make choices regarding the system based on the intended use of the spaces, occupants' comfort, and energy and economic aspect; 2) perform, also using software, calculations of winter and summer thermal loads of the system; 3) assess, also using software, the energy requirements and energy class of the system according to current standards and in relation to winter heating, summer cooling, and domestic hot water production in the current scenario and in that relating to a possible system upgrade; 4) carry out the design and regulation of various components of the system (heat-chilling plant, distribution network of thermal fluid carriers, heat exchange terminals, control system) using specific software, also with a BIM (Building Information Modelling) approach..

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:

The examination takes place through an oral interview aimed at verifying the understanding of theoretical principles and analysis and synthesis methodologies presented during the lessons. The assessment will take into account the results of a written test and the project work.

Course:	**Teaching Language:**
IMPIANTI DI GENERAZIONE TERMICA *HEAT GENERATION PLANTS*	ITALIAN

SSD (SUBJECT AREAS):	**CREDITS:**
IIND-06/B (EX ING-IND/09)	9

Course year: I or II	**Type of Educational Activity: B**

Teaching Methods:

In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:

The discipline covers the energy conversion systems from conventional sources (fossil fuels and nuclear reactor fuels) and renewable ones (solar, wind, hydro and tidal, geothermal, from biomass and solid wastes). Of interest are the production and usage of alternative fuels, driving systems, thermal plants, heat and refrigeration pumps, as well as the fluid-based energy systems, the energy transportation process, the energy recovery and storage systems, and their role inside smart grids. Likewise, fluid power components and devices finalized at direct energy conversion process are of relevance. The scientific and educational aspects of the above-mentioned energy systems and of the related machineries deal with thermodynamic, fluid-dynamic, technology, safety, diagnostic and control issues, with a particular focus on the environmental impact and on the technologies specifically designed for their mitigation or abatement. Those aspects are analyzed in an energy planning context at several scales not disregarding the sustainability of the various process, systems and components within their life cycle.

Objectives:

The course enables the student to acquire the ability to perform professional work in the specific field, highlighting both the technical and economic aspects of the design, installation and operation of thermal generation systems, using what has been gained in previous and collateral courses. The course also transmits scientific and professional knowledge about thermal generation plants, underlining the multiplicity of connections with basic phenomenologies and related cultural areas.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:

Oral

Course:	**Teaching Language:**
IMPIANTI DI PRODUZIONE DA FONTI TRADIZIONALI E RINNOVABILI *ELECTRIC POWER PLANTS BASED ON TRADITIONAL AND RENEWABLE SOURCES*	ITALIAN
SSD (SUBJECT AREAS): IIND-08/B (EX ING-IND/33)	**CREDITS:** 6
Course year: I or II	**Type of Educational Activity: C, D**

Teaching Methods:

In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:

The scientific disciplinary field is concerned with scientific and educational activity related to interconnected plants, networks and systems of components and apparatuses that use energy-significant electric carriers for production, transmission, distribution, distributed generation, storage and utilization of electric energy. This includes industrial electrical systems, smart grids, microgrids, energy communities, electric mobility and transportation systems, special electrical systems, lighting systems, building automation and home automation. Related to this context are the planning, design, implementation, management, supervision, control, and diagnostics of electrical systems, including materials, components, and technologies. Of particular interest are: reliability, resilience, quality, safety, electromagnetic compatibility, sustainability, interconnection of energy systems and integration of renewables, and electricity markets and economics. Methodologies and tools used include deterministic and probabilistic models, data analysis, simulation, experimentation, optimization, forecasting, ICT technologies, digitization, power electronics, automation, artificial intelligence, big data, and digital twin.

Objectives:

The course aims at providing students with advanced notions related to: (i) electrical systems in power plants connected to low, medium, and high voltage networks; (ii) participation of power generation units to the electrical energy market; (iii) models for the electrical energy market

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:

Orale

Course: IMPIANTI IDROELETTRICI *HYDROELECTRIC SYSTEMS*	**Teaching Language:** ITALIAN
SSD (SUBJECT AREAS): CEAR-01/B (EX ICAR/02)	**CREDITS:** 9
Course year: I or II	**Type of Educational Activity: C, D**

Teaching Methods:
In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:
The scientific disciplinary field develops water cycle issues in relation to the design, construction, and operation of civil works and infrastructure and the design of sustainable strategies for soil and coastal defense, environmental protection, water resources management, and adaptation to climatic and environmental variations. Deals with theoretical and applied aspects of hydrological science and water engineering, with reference to: meeting water needs; protection of people, the man-made and natural environment from floods, drought, storm surges, water-triggered flows and landslides, pollutants and pathogens in surface and groundwater; interactions with the atmosphere and ecosystems. Application domains include monitoring and modeling of hydrological processes; infrastructure for storage, regulation, adduction, distribution, drainage, and energy production; control and monitoring of water in urban, agricultural, and industrial settings; waterways; and maritime, river, slope, and coastal works, within a vision of integrated hydraulic and hydrological risk management.

Objectives:
Acquire specific knowledge in the hydraulic energy sector, also considering the environmental impact of the plants, with particular regard to the following sectors: large-scale hydroelectric plants; small hydroelectric power generation (pico, micro, mini and small hydro); technical -economic feasibility analysis.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:
Oral, project discussion

Course: IMPIANTI PER L'ENERGIA SOLARE *SOLAR ENERGY TECHNOLOGIES*	**Teaching Language:** ITALIAN
SSD (SUBJECT AREAS): IIND-07/A (EX ING-IND/10)	**CREDITS:** 6
Course year: II	**Type of Educational Activity: B**

Teaching Methods:

In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:

The group includes skills relating to the following topics: thermodynamic, thermokinetic analysis of energy processes and their environmental impact, principles, methodologies and technologies for sustainable energy conversion from renewable and conventional energy sources, final uses of energy, energy management, techniques for monitoring and processing energy data and models, energy efficiency technologies and applications, thermoeconomics, technologies for the energy transition, physics of the built environment, with particular reference to the interaction among occupants and the environment, thermophysics of buildings, technical plants for civil applications, energy diagnosis and optimization of the building-plant-territory system, applied acoustics, lighting engineering, air quality, passive systems and plant technologies for air conditioning and environmental well-being. It also studies thermo-fluid-dynamic phenomena in biological and agri-food systems, refrigeration technologies, thermotechnics, heat exchange and energy storage systems and components, fire safety, thermophysical properties of materials, measurements and thermo-fluid-dynamic controls, materials for energy, acoustics and lighting engineering.

Objectives:

The course aims at providing theoretical and applied knowledge of systems for the solar conversion into useful thermal and electricity. Starting by the fundamentals of the solar energy and its conversion principle and associated limits, the course will provide the base for the preliminary design of a solar based system according to the application and environmental conditions. Finally, the design principles of the different solar thermal and photovoltaic plants will be provided together with the basis of modelling, simulation and optimization for the system optimal design and operation according to different objective functions. The course will provide the students with the technical and decision-making skills to design and operate in the field of solar-based systems.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:

Orale

Course:	**Teaching Language:**
INGEGNERIA DEI MATERIALI NANOFASICI PER L'ENERGETICA E LA SENSORISTICA *NANOPHASIC MATERIAL ENGINEERING FOR ENERGY AND SENSORS*	ITALIAN
SSD (SUBJECT AREAS): IMAT-01/A (EX ING-IND/22)	**CREDITS:** 6
Course year: I or II	**Type of Educational Activity: C, D**

Teaching Methods:

In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:

The scientific disciplinary field is concerned with scientific and educational activity in the field of Materials Science and Technology and in particular encompasses the body of knowledge related to materials, both structural and functional, having technical and engineering interest. Strongly characterizing the field is the study of the link between the structural, microstructural, and functional properties of materials and their macroscopic properties, performance, and transformation and production processes. More specifically, the field studies: - the relationships between the structure of materials at all dimensional scales (from nano to macro), formulation, design, properties (chemical, biochemical, physical, mechanical, surface, and biocompatibility), and performance; - traditional and innovative technologies of materials production, processing, and transformation, as well as those related to analysis, characterization, and quality control; hybrid system interfaces, surface treatments with and without material input, and the set of methodologies, techniques, and treatments for functionalization; - methodologies and processes for contextual fabrication of the material and component; - in-service behavior, durability, corrosion and wear resistance, degradation, preservation, restoration, protection technologies, environmental protection and sustainability technologies, reuse and recycling with material and energy recovery, and life cycle analysis. The field deals with metallic materials and their alloys, ceramic materials and glasses, polymeric materials and plastics, cementitious materials and binders, semiconductors, biomaterials, the multimaterial combinations and composites, both natural and man-made. Teaching activities cover the disciplines, both basic and specialized, typical of engineering and materials science and technology.

Objectives:

The student will acquire knowledge of the methods used to engineer functional properties of nanophase materials, both those most commonly used and those still in the experimental phase. The student will also develop an understanding of the mechanisms underlying the applications of nanophase materials in different optoelectronic and biological technologies. Finally, he will acquire an overview of the current manufacturing procedures and those potentially usable in industrial practice.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:

Seminars held and final interview

Course: INQUINANTI ATMOSFERICI DA ATTIVITÀ ANTROPICHE *POLLUTANT FORMATION AND CONTROL*	**Teaching Language:** ITALIAN
SSD (SUBJECT AREAS): ICHI-02/A (EX ING-IND/25)	**CREDITS:** 6
Course year: I	**Type of Educational Activity: C**

Teaching Methods:
In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:
The scientific discipline includes the study of methodologies for the design, realization, verification and operation of industrial plants based on chemical-physical and biological transformations of matter aimed at the production of goods, the provision of services and the prevention or mitigation of modifications to the environment induced by human activities or settlements. Qualifying for the field, in both scientific and didactic-training activities, are: plant design including simulation, elaboration of quantified process and functional schemes including protection and control instrumentation; selection, design, prototyping and verification of reactors and equipment for unit operations and development of related experimental methodologies; safety and risk analysis of plants and processes; and economic, sustainability and environmental impact assessments also examined in the context of industrial ecology. Areas of focus are chemical, pharmaceutical, food, energy, extraction, refining, transport and storage technologies for raw materials and energy carriers; biotechnology; and technologies supporting environmental protection and the circular economy.

Objectives:
The course provides a detailed knowledge of the formation mechanisms of pollutants by anthropogenic activities to properly understand environmental problems and the relationship between anthropogenic activities and effects on the environment and human health. The ultimate goal is to provide tools and methodologies for the correct implementation of environmental policies.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:
Oral

Course:	**Teaching Language:**
LABORATORIO DI OTTIMIZZAZIONE DI SISTEMI TERMODINAMICI *LABORATORY OF THERMODYNAMIC SYSTEMS OPTIMIZATION*	ITALIAN
SSD (SUBJECT AREAS):	**CREDITS:**
IIND-07/A (EX ING-IND/10)	6
Course year: I	**Type of Educational Activity: B**

Teaching Methods:

In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:

The group includes skills relating to the following topics: thermodynamic, thermokinetic analysis of energy processes and their environmental impact, principles, methodologies and technologies for sustainable energy conversion from renewable and conventional energy sources, final uses of energy, energy management, techniques for monitoring and processing energy data and models, energy efficiency technologies and applications, thermoeconomics, technologies for the energy transition, physics of the built environment, with particular reference to the interaction among occupants and the environment, thermophysics of buildings, technical plants for civil applications, energy diagnosis and optimization of the building-plant-territory system, applied acoustics, lighting engineering, air quality, passive systems and plant technologies for air conditioning and environmental well-being. It also studies thermo-fluid-dynamic phenomena in biological and agri-food systems, refrigeration technologies, thermotechnics, heat exchange and energy storage systems and components, fire safety, thermophysical properties of materials, measurements and thermo-fluid-dynamic controls, materials for energy, acoustics and lighting engineering.

Objectives:

The objective of the course is to provide knowledge and specific skills about advanced modeling and optimization of thermodynamic systems. The student will learn different methodological tools, such as: modeling (including data fitting and artificial neural networks), optimization (including genetic algorithm techniques), critical analysis of the results in multi-objective optimization problems (for instance: total costs versus overall performance of the system for long periods). After an overview of available models for the description of single components and thermodynamic systems (plants used for electric, thermal and/or cold energy “production”, from both conventional and renewable sources), the student will learn how to apply thermodynamic models and optimization techniques through a complex case study, with multiple users with thermal, cold and electric energy requirements, with different scenarios related to the electric energy cost, with the purpose to apply the optimization techniques to the specific case study.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:

Oral exam and project discussion

Course: LIGHTING TECHNOLOGY AND APPLIED ACOUSTICS *ILLUMINOTECNICA E ACUSTICA APPLICATA*	**Teaching Language:** ENGLISH
SSD (SUBJECT AREAS): IIND-07/A (EX ING-IND/10)	**CREDITS:** 6
Course year: II	**Type of Educational Activity: B**

Teaching Methods:

In presence

Contents extracted from the SSD declaratory consistent with the training objectives of the course:

Skills relating to the following topics: […],applied acoustics, lighting engineering […]. It also studies […] materials for energy, acoustics and lighting engineering.

Objectives:

The main objective of this course is to provide students with the basic knowledge of lighting technology and applied acoustics, necessary to obtain optimal environmental conditions. Specifically, students will be acquainted with quantities and will be able to link the physiological and perceptual aspects of vision to quantitative parameters for light environmental quality assessment, by evaluating visual performance and comfort, chromatic aspects and non-visual effects of light. Students will acquire the ability to evaluate lighting systems based on technical characteristics of luminaires and automatic control systems.

Furthermore, the course aims to make students aware of all acoustic phenomena related to the propagation, description and perception of sound as well as the use of traditional and innovative materials for noise control. Students will acquire tools for studying and evaluating the sound field in small and large spaces confined environments, vibro-acoustic interactions between air and solid structures and technologies for improving acoustic insulation. Finally, issues concerning with the measurement and analysis of the sound emitted by industrial products will be explored in depth.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:

The exam consists of an oral interview

Course: LOW CARBON BOILERS AND INDUSTRIAL FURNACES *CALDAIE A BASSA CO_2 E FORNACI INDUSTRIALI*	**Teaching Language:** ENGLISH
SSD (SUBJECT AREAS): IIND-06/B (ex ING-IND/09)	**CREDITS:** 6
Course year: II	**Type of Educational Activity: B**

Teaching Methods:
In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:
The discipline covers the scientific and educational issues related to thermodynamic, fluid dynamic, aero-acoustic, aero-mechanic, energetic, technological, environmental and sustainability problems of [...] fluid-based energy conversion systems. Of interest are the design, control, diagnostic, optimization, operation, testing, commissioning and environmental impact of [...] power systems [...]. Likewise, devices involving chemical reactions (such as combustors, gasifier, reactors, fuel cells and reverse electrolysis systems) and heat transfer (such as evaporators, condensers and recuperators) are issues of relevance. Further, the integration of those machineries and devices into more complex systems aimed at the generation, conversion, storage, and distribution of electrical and thermal energy[...]. Finally, process engineering and service applications are also envisaged.

Objectives:
Provide skills relating to the energy needs of particularly energy-intensive (hard-to-abate) sectors and on current high-temperature heat production techniques, both for steam generators and industrial furnaces (production of steel, glass, aluminium, etc.). Acquire knowledge relating to the convective and radiative heat exchange mechanisms in energy intensive plants and the mechanisms of production, mitigation and abatement of polluting substances connected to these processes. Quantify the carbon footprint of the hard-to-abate processes and acquire knowledge relating to the technologies in use and under development for the reduction of the production of carbon dioxide connected to that energy processes, such as for example the use of alternative fuels with reduced or zero content of carbon (e-fuels, ammonia, hydrogen and their mixtures). Evaluate the influence of alternative fuels on the management of combustion processes, on heat exchange mechanisms and on the production of pollutants. Analyse energy and environmental opportunities and problems relating to the use of biomass in the industrial sector. Analyse concentrated solar heating in industrial processes.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:
Oral

Course: MACHINE LEARNING AND BIG DATA *APPRENDIMENTO AUTOMATICO E BIG DATA*	**Teaching Language:** ENGLISH
SSD (SUBJECT AREAS): IINF-05/A (EX ING-INF/05)	**CREDITS:** 9
Course year: I or II	**Type of Educational Activity: D**

Teaching Methods:
In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:
The scientific disciplinary group covers scientific and educational activity in the field of Computer Engineering. The competencies of the group cover models, methodologies, principles and techniques specific to the analysis, design, development and conduct of information systems. This also applies with reference to multidisciplinary areas such as digital humanities, smart mobility, cultural heritage, e-health, smart cities, e-government, legal informatics, and smart manufacturing. The group covers research topics that can be organized into the following research domains: - Computing system architectures, which includes embedded, real-time and cyber-physical systems, architectures for energy-efficient, high-performance and quantum computing, tools for modeling, simulation, and automatic design of digital systems; - Distributed and parallel systems, which includes operating systems, computer networks, computing aspects of IoT, cloud-edge systems, and performance evaluation tools; - software engineering: includes methodologies, programming languages, software infrastructures and related tools; - algorithm engineering and theoretical computer science, which includes computational complexity, distributed, parallel, on graphs, quantum algorithms, algorithmic game theory, formal methods and computational models; - computer security, which includes computing techniques for cybersecurity and privacy, cryptography and computer network security; - artificial intelligence, which includes autonomous and intelligent robotics, intelligent systems, knowledge engineering and natural language processing; - graphics, computer vision and multimedia: includes image, video and sound processing, computer games and virtual reality; - human-computer interaction, which includes user-centered design, quality of user experience and information visualization; - databases and information systems, which includes Web technologies, information retrieval, digital libraries, data transformation and integration, Big Data and data management in bioinformatics; - machine learning, which includes data mining, process mining, computer aspects of data science and signal processing and recognition techniques, sensory data processing in robotics, and biological and biomedical data analysis. Teaching activities cover the spectrum from the various specialized domains to basic training in the use, in all fields, of methodological and technological approaches specific to computer engineering. Theoretical foundations, methods, and technologies for defining requirements, designing, developing, evaluating, and managing computer systems, ensuring their adequacy, correctness, reliability, performance, security, cost-effectiveness, sustainability, and ethical compliance fall within the scope of the group.

Objectives:
The aim of the course is to present the main machine learning techniques, covering all aspects from data preparation to performance evaluation, through practical exercises carried out with commercial and/or open-source tools. An introduction to Big Data and Data Analytics lifecycle is also provided, with reference to the design of large and complex databases, and to the process of modeling, acquiring, sharing, analyzing and visualizing the information embedded into Big Data.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:
Oral

Course: MATERIALI E TECNOLOGIE PER IL FOTOVOLTAICO *MATERIALS AND TECHNOLOGIES FOR PHOTOVOLTAIC*	**Teaching Language:** ITALIAN
SSD (SUBJECT AREAS): IMAT-01/A (EX ING-IND/22)	**CREDITS:** 6
Course year: I or II	**Type of Educational Activity: D**

Teaching Methods:
In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:
The scientific disciplinary field is concerned with scientific and educational activity in the field of Materials Science and Technology and in particular encompasses the body of knowledge related to materials, both structural and functional, having technical and engineering interest. Strongly characterizing the field is the study of the link between the structural, microstructural, and functional properties of materials and their macroscopic properties, performance, and transformation and production processes. More specifically, the field studies: - the relationships between the structure of materials at all dimensional scales (from nano to macro), formulation, design, properties (chemical, biochemical, physical, mechanical, surface, and biocompatibility), and performance; - traditional and innovative technologies of materials production, processing, and transformation, as well as those related to analysis, characterization, and quality control; hybrid system interfaces, surface treatments with and without material input, and the set of methodologies, techniques, and treatments for functionalization; - methodologies and processes for contextual fabrication of the material and component; - in-service behavior, durability, corrosion and wear resistance, degradation, preservation, restoration, protection technologies, environmental protection and sustainability technologies, reuse and recycling with material and energy recovery, and life cycle analysis. The field deals with metallic materials and their alloys, ceramic materials and glasses, polymeric materials and plastics, cementitious materials and binders, semiconductors, biomaterials, the multimaterial combinations and composites, both natural and man-made. Teaching activities cover the disciplines, both basic and specialized, typical of engineering and materials science and technology.

Objectives:
Introduction to the production of solar energy from photovoltaics. Basic operating principles of photovoltaics. Traditional photovoltaic materials, including silicon in its various forms and different compositions of chalcogens. Organic photovoltaic materials, small molecules and polymers, and hybrids organic-inorganic, with particular emphasis on recent developments related to peroschites. Integration of materials in photovoltaic devices and modules. Characterizations and measurement methods of materials and photovoltaic devices. Future developments of photovoltaic materials and systems. The role of photovoltaics in the energy system of the future.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:
Seminari intercorso e colloquio finale

Course:	**Teaching Language:**
MATHEMATICAL MODELS AND COMPUTATIONAL METHODS FOR ENGINEERING *MODELLI MATEMATICI E METODI COMPUTAZIONALI PER L'INGEGNERIA*	ENGLISH

SSD (Subject Areas):	**CREDITS:**
MATH-04/A (ex MAT/07)	9

Course year: I	**Type of Educational Activity: D**

Teaching Methods:

in-person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:

The scientific disciplinary field is concerned, both from a theoretical and applied point of view, with the scientific and didactic-training activities of Mathematical Physics that have as their main object the treatment and solution of mathematical problems suggested by physical theories and, more generally, mathematical models of relevant interest to scientific disciplines, industrial development and the description of social and economic phenomena, using rigorous mathematical tools and an axiomatic-deductive approach. The field is primarily concerned with the structures and mathematical aspects relevant to physics, and in particular those related to: rational mechanics of discrete and continuous systems; dynamical systems and celestial mechanics; classical, quantum and relativistic field theories; quantum, relativistic and statistical mechanics; kinetic theories and diffusion and transport phenomena. In addition, the field is concerned with the development of rigorous mathematical models, both deterministic and stochastic, for the description of phenomena in the biomathematical, social, economic, and industrial domains as well as with the physico-mathematical aspects of artificial intelligence and data analysis. In terms of methodologies, the field makes use of rigorous analytical, probabilistic, algebraic, geometric and computational mathematical techniques. Teaching skills cover, in addition to the above topics and the core teachings of the field, all teachings related to basic mathematics content.

Objectives:

The aim of the course is to introduce the fundamental principles of mathematical modeling for formalizing and solving engineering problems. The course will provide basic knowledge of partial differential equations in Mathematical Physics and their applications, and will discuss computational methods (i.e., finite difference and finite element) for parabolic, hyperbolic, and elliptic problems. The course will also cover various resolution methods for nonlinear ordinary differential equations of interest for Mathematical Physics (i.e., Lagrangian and Hamiltonian models). The numerical discussion of each type of equation will always be preceded by the introduction and derivation of the models. Moreover, the role of initial and boundary conditions will be highlighted with reference to physical situations. The numerical investigation will involve the development of specific applications on the MATLAB platform.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:

The exam is constituted by an oral test to verify student knowledge and the discussion of a project which can be developed in groups (2-4 people) and is related to the application of the studied methodologies to an engineering problem selected in agreement with the Instructor. The evaluation will be quantified as follows: 50% for the oral exam and 50% for the project quality and defence.

Course: MECCANICA DEL VEICOLO *VEHICLE DYNAMICS*	**Teaching Language:** ITALIAN
SSD (SUBJECT AREAS): IIND-02/A (EX ING-IND/13)	**CREDITS:** 9
Course year: I	**Type of Educational Activity: D**

Teaching Methods:
In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:
The scientific disciplinary field is concerned with scientific and educational activity in the field of Applied Mechanics of Machines. It includes the cultural, scientific, professional and historical aspects inherent in the study of mechanical systems, machines, their components and structures. The study is approached, with a unifying systems approach, through the methodologies proper to theoretical, applied and experimental mechanics, leading to technological and industrial application, with attention to environmental and energy sustainability. The typology of mechanical systems considered is entirely general: driving and operating machines, mechanical and mechatronic devices, mechanisms, transmissions and drives, automatic machines and robotic systems, vehicles, conventional and autonomous transportation systems, lifting systems, energy production systems, biomechanical systems, and micro- and nano-scale components and systems. The field uses experimental, modeling and simulation methods for the analysis of mechanical behavior, functional design of machines and mechanical systems. Methods and applications are based on the study of kinematics, statics, dynamics, linear and nonlinear, interactions with the environment in general and between material surfaces (contact mechanics), control, automation and identification of mechanical systems. Interests in the field also include vibratory, vibroacoustic and tribological phenomena, mechatronics, fluid-structure interactions, monitoring, diagnostics and prognostics of mechanical systems, fluid automation and robotics, fluidics and microfluidics, and functional biomechanics. Implementation through hardware and software systems of the developed methods is an integral part of the knowledge of the field.

Objectives:
The aim of the course is to introduce the fundamentals of road vehicle dynamics. The course aims to provide methodologies to approach the study of road vehicles dynamics, based on the use of deductively developed physical-analytical models. The main problems concerning the tire-road interaction, the longitudinal, lateral and vertical dynamics of the vehicle are addressed.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:
Oral

Course: MISURE TERMOFLUIDODINAMICHE *THERMO-FLUID-DYNAMIC MEASUREMENTS*	**Teaching Language:** ITALIAN
SSD (SUBJECT AREAS): IIND-07/A (EX ING-IND/10)	**CREDITS:** 9
Course year: II	**Type of Educational Activity: B**

Teaching Methods:
In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:
The group includes skills relating to the following topics: thermodynamic, thermokinetic analysis of energy processes and their environmental impact, principles, methodologies and technologies for sustainable energy conversion from renewable and conventional energy sources, final uses of energy, energy management, techniques for monitoring and processing energy data and models, energy efficiency technologies and applications, thermoeconomics, technologies for the energy transition, physics of the built environment, with particular reference to the interaction among occupants and the environment, thermophysics of buildings, technical plants for civil applications, energy diagnosis and optimization of the building-plant-territory system, applied acoustics, lighting engineering, air quality, passive systems and plant technologies for air conditioning and environmental well-being. It also studies thermo-fluid-dynamic phenomena in biological and agri-food systems, refrigeration technologies, thermotechnics, heat exchange and energy storage systems and components, fire safety, thermophysical properties of materials, measurements and thermo-fluid-dynamic controls, materials for energy, acoustics and lighting engineering.

Objectives:
The course aims to introduce students to basic measurement and data analysis techniques. Students become familiar with the vocabulary of basic measurement science, various types of measurement systems and techniques of measurement and control of mechanical and thermal quantities for energy applications.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:
Written and oral

Course: MODELLAZIONE GEOMETRICA PER L'ENERGIA E L'AMBIENTE *GEOMETRICAL MODELLING FOR ENERGY AND ENVIRONMENT*	**Teaching Language:** ITALIAN
SSD (SUBJECT AREAS): IIND-03/B (EX ING-IND/15)	**CREDITS:** 9
Course year: I	**Type of Educational Activity: D**

Teaching Methods:

In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:

The scientific disciplinary area conducts research on methods and tools for modeling (conceptual, geometric, morphological, and functional), simulation, development, and systematic innovation of products, machines, and systems, including the synthesis of design specifications, regulatory, aesthetic, and social impact constraints. Topics of interest in the field include: user-oriented design, physical and cognitive ergonomics, sustainability and manufacturability; product lifecycle management using all computer-aided tools; dimensional and geometric specification, virtual prototyping, digital human modelling, human-machine interaction, reverse engineering and geometric reconstruction, image processing, additive manufacturing, digital twin, extended reality and knowledge engineering in numerous application areas. Teaching focuses on methods and tools, including computer-based tools, to support all stages of product and process development in both the core subjects of drawing, technical representation and digital modeling and the specialized subjects on research topics that characterize the field.

Objectives:

Study and use of the most advanced methodologies for the design, modeling and management of complex systems of mechanical interest in the context of systems and plants for the production, transmission and use of energy by means of 3D CAD software. Ability to import information and manage mathematics in a CAD environment and export models useful for multi-physical FEM analyzes (fluid dynamics, structural and thermal). Ability to interpret and manage complex designs and analyze design problems with an interdisciplinary approach.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:

Written and oral

Course: MODELLISTICA E OTTIMIZZAZIONE DI SISTEMI DI PROPULSIONE *MODELING AND OPTIMIZATION OF POWER UNITS*	**Teaching Language:** ITALIAN
SSD (SUBJECT AREAS): IIND-06/A (ex ING-IND/08)	**CREDITS:** 6
Course year: II	**Type of Educational Activity: B**

Teaching Methods:
In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:
The discipline covers the scientific and educational issues related to thermodynamic, fluid dynamic, aero-acoustic, aero-mechanic, energetic, technological, environmental and sustainability problems of all fluid machinery and fluid-based energy conversion systems. Of interest are the design, control, diagnostic, optimization, operation, testing, commissioning and environmental impact of fluid machinery and power systems (such as turbines, expanders, internal combustion engines possibly integrated into hybrid propulsion systems, fluid power systems), as well as fans, compressors and pumps. Likewise, devices involving chemical reactions (such as combustors, gasifier, reactors, fuel cells and reverse electrolysis systems) and heat transfer (such as evaporators, condensers and recuperators) are issues of relevance. Further, the integration of those machineries and devices into more complex systems aimed at the generation, conversion, storage, and distribution of electrical and thermal energy, as well as their usage for land, aerial and naval propulsion applications is of interest. Finally, process engineering and service applications are also envisaged.

Objectives:
The course aims to present the main numerical methodologies for the optimal design and analysis of internal combustion engines (ICEs). Students will be provided with the elements necessary for the correct interpretation of the results that can be obtained with the different modeling approaches (0D-1D-3D), highlighting their limits and potential. The course will focus on modeling the phenomena inside and outside the cylinders and it will broaden the analysis to the entire engine-vehicle system, (traditional or hybrid), for the forecast of CO2 emissions. The use of engine simulation software and optimization codes of wide industrial use is envisaged.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:
Project discussion

Course: MOTORI A COMBUSTIONE INTERNA *INTERNAL COMBUSTION ENGINES*	**Teaching Language:** ITALIAN
SSD (SUBJECT AREAS): IIND-06/A (ex ING-IND/08)	**CREDITS:** 9
Course year: I	**Type of Educational Activity: B**

Teaching Methods:
In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:
The discipline covers the scientific and educational issues related to thermodynamic, fluid dynamic, aero-acoustic, aero-mechanic, energetic, technological, environmental and sustainability problems of all fluid machinery and fluid-based energy conversion systems. Of interest are the design, control, diagnostic, optimization, operation, testing, commissioning and environmental impact of fluid machinery and power systems (such as turbines, expanders, internal combustion engines possibly integrated into hybrid propulsion systems, fluid power systems), as well as fans, compressors and pumps. Likewise, devices involving chemical reactions (such as combustors, gasifier, reactors, fuel cells and reverse electrolysis systems) and heat transfer (such as evaporators, condensers and recuperators) are issues of relevance. Further, the integration of those machineries and devices into more complex systems aimed at the generation, conversion, storage, and distribution of electrical and thermal energy, as well as their usage for land, aerial and naval propulsion applications is of interest. Finally, process engineering and service applications are also envisaged.

Objectives:
The aim of the course, having taken into account the basic elements studied in the "Fluid Machines" course of the 1st level, is to deepen and specialize the fundamental issues for a mechanical energy engineer connected with the generation of torque at the axis output of an Internal combustion engine.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:
Oral

Course: NETWORK SECURITY *SICUREZZA INFORMATICA*	**Teaching Language:** ITALIAN
SSD (SUBJECT AREAS): IINF-05/A (EX ING-INF/05)	**CREDITS:** 6
Course year: I or II	**Type of Educational Activity: D**

Teaching Methods:
In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:
The scientific disciplinary group covers scientific and educational activity in the field of Computer Engineering. The competencies of the group cover models, methodologies, principles and techniques specific to the analysis, design, development and conduct of information systems. This also applies with reference to multidisciplinary areas such as digital humanities, smart mobility, cultural heritage, e-health, smart cities, e-government, legal informatics, and smart manufacturing. The group covers research topics that can be organized into the following research domains: - Computing system architectures, which includes embedded, real-time and cyber-physical systems, architectures for energy-efficient, high-performance and quantum computing, tools for modeling, simulation, and automatic design of digital systems; - Distributed and parallel systems, which includes operating systems, computer networks, computing aspects of IoT, cloud-edge systems, and performance evaluation tools; - software engineering: includes methodologies, programming languages, software infrastructures and related tools; - algorithm engineering and theoretical computer science, which includes computational complexity, distributed, parallel, on graphs, quantum algorithms, algorithmic game theory, formal methods and computational models; - computer security, which includes computing techniques for cybersecurity and privacy, cryptography and computer network security; - artificial intelligence, which includes autonomous and intelligent robotics, intelligent systems, knowledge engineering and natural language processing; - graphics, computer vision and multimedia: includes image, video and sound processing, computer games and virtual reality; - human-computer interaction, which includes user-centered design, quality of user experience and information visualization; - databases and information systems, which includes Web technologies, information retrieval, digital libraries, data transformation and integration, Big Data and data management in bioinformatics; - machine learning, which includes data mining, process mining, computer aspects of data science and signal processing and recognition techniques, sensory data processing in robotics, and biological and biomedical data analysis. Teaching activities cover the spectrum from the various specialized domains to basic training in the use, in all fields, of methodological and technological approaches specific to computer engineering. Theoretical foundations, methods, and technologies for defining requirements, designing, developing, evaluating, and managing computer systems, ensuring their adequacy, correctness, reliability, performance, security, cost-effectiveness, sustainability, and ethical compliance fall within the scope of the group

Objectives:
The aim of the class is to provide students with advanced notions in the field of network security. Students will become familiar with well-known security mechanisms and attack mitigation techniques, by focusing on the solutions available at the various levels of the networking stack, from the physical layer up to the application layer. The class leverages some of the basic security concepts, with special reference to symmetric encryption and message confidentiality, as well as public key cryptography and message authentication. On the other hand, it paves the ground to some of the core topics addressed within Software Security, like, e.g., buffer overflow attacks and fuzzing techniques.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:
Discussione di un elaborato + prova orale

Course: OLEODINAMICA E PNEUMATICA *FLUID POWER AND PNEUMATIC SYSTEMS*	**Teaching Language:** ITALIAN
SSD (SUBJECT AREAS): IIND-06/B (EX ING-IND/09)	**CREDITS:** 9
Course year: II	**Type of Educational Activity: B**

Teaching Methods:
In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:
The discipline covers the energy conversion systems from conventional sources (fossil fuels and nuclear reactor fuels) and renewable ones (solar, wind, hydro and tidal, geothermal, from biomass and solid wastes). Of interest are the production and usage of alternative fuels, driving systems, thermal plants, heat and refrigeration pumps, as well as the fluid-based energy systems, the energy transportation process, the energy recovery and storage systems, and their role inside smart grids. Likewise, fluid power components and devices finalized at direct energy conversion process are of relevance. The scientific and educational aspects of the above-mentioned energy systems and of the related machineries deal with thermodynamic, fluid-dynamic, technology, safety, diagnostic and control issues, with a particular focus on the environmental impact and on the technologies specifically designed for their mitigation or abatement. Those aspects are analyzed in an energy planning context at several scales not disregarding the sustainability of the various process, systems and components within their life cycle.

Objectives:
The aim of the course is to introduce, deepen and specialize the issues for a mechanical engineer regarding hydraulic drives. Therefore being able to define a service in terms of forces or torques required, actuation time and a sequence of operations he must be able to design the system capable of realizing it.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:
Oral

Course: PRINCIPLES AND APPLICATIONS OF FLUID MACHINERY *PRINCIPI E APPLICAZIONI DELLE MACCHINE A FLUIDO*	**Teaching Language:** ENGLISH
SSD (Subject Areas): IIND-06/A (EX ING-IND/08)	**CREDITS:** 9
Course year: I	**Type of Educational Activity: B**

Teaching Methods: in-person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:

The discipline covers the scientific and educational issues related to thermodynamic, fluid dynamic […] problems of all fluid machinery and fluid-based energy conversion systems. Of interest are the design, […], optimization, operation, testing […] of fluid machinery and power systems (such as turbines […]), as well as fans, compressors and pumps. […].

Objectives:

The purpose of the course is to provide the students with the knowledge needed for an accurate study of fluid machines and energy conversion systems, which are considered to be fundamental subjects dealt with in the second level degree in Energy and Environmental Mechanical Engineering. The general scheme of the course envisages the study of the thermofluid dynamic fundamentals of fluid machines and energy systems with practical examples. The course focuses on the study of turbomachines, as standalone components or part of a power plant. The course deepens the analysis of the thermodynamic processes taking place in fluid machines, the evaluation of the mechanical energy transfer, the flow in variable-area ducts, the dimensional analysis, the operating curves and the aerodynamics of airfoils and blade cascades.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:

Oral

Course: PROGETTAZIONE ASSISTITA DI STRUTTURE MECCANICHE *COMPUTER AIDED DESIGN OF MECHANICAL STRUCTURES*	**Teaching Language:** ITALIAN
SSD (SUBJECT AREAS): IIND-03/A (EX ING-IND/14)	**CREDITS:** 9
Course year: I	**Type of Educational Activity: D**

Teaching Methods:
In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:
The scientific activity of the disciplinary scientific area focuses on mechanical design, construction of mechanical machines and systems, including: elements, connections, structures, devices and interfaces. Theoretical and methodological, experimental and numerical knowledge is developed for the analysis of stresses and static and dynamic behavior of systems, structures, components and materials and for the evaluation of functionality and integrity in order to ensure safety, reliability, manufacturability, usability, maintainability and sustainability. Methodologies, applied at all dimensional scales with integration and aid of digital innovations, include theoretical and phenomenological modeling, numerical simulation, experimental and computational techniques, and functional and structural optimization. Instructional activities cover all phases of mechanical design: specification definition, feasibility analysis, conceptual and detailed design, structural analysis, prototyping, virtual and experimental validation, and product planning.

Objectives:
The aim of course is to provide knowledge of the FEM (Finite Element Method) numerical methodology for structural analysis, as well as basic knowledge of alternative numerical methodologies such as multybody and BEM (Boundary Element Method), acquiring applicative skills in fundamental topics..

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:
Project work e orale

Course: PROGETTO DI MACCHINE *FLUID MACHINERY DESIGN PRINCIPLES*	**Teaching Language:** ITALIAN
SSD (SUBJECT AREAS): IIND-06/A (ex ING-IND/08)	**CREDITS:** 9
Course year: II	**Type of Educational Activity: B**

Teaching Methods:

In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:

The discipline covers the scientific and educational issues related to thermodynamic, fluid dynamic […] problems of all fluid machinery and fluid-based energy conversion systems. Of interest are the design, […] optimization, operation, testing […] of fluid machinery and power systems (such as turbines […]), as well as fans, compressors and pumps. […]

Objectives:

The course provides basic knowledge of the aero-thermal design principles of fluid machinery. Technical aspects concerning guidelines to establish the most relevant geometrical features of conventional fluid machinery are dealt with a fluid dynamic approach.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:

Oral / Project discussion

Course: REFRIGERATION AND HEAT PUMP TECHNOLOGIES *TECNOLOGIE PER LA REFRIGERAZIONE E POMPE DI CALORE*	**Teaching Language:** ENGLISH
SSD (SUBJECT AREAS): IIND-07/A (EX ING-IND/10)	**CREDITS:** 9
Course year: II	**Type of Educational Activity: B**

Teaching Methods:

In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:

Skills relating to the following topics: thermodynamic, thermokinetic analysis of energy processes and their environmental impact, principles, methodologies and technologies for sustainable energy conversion from renewable and conventional energy sources, final uses of energy, energy management, techniques for monitoring and processing energy data and models, energy efficiency technologies and applications, thermoeconomics, technologies for the energy transition. It also studies refrigeration technologies, heat exchange and thermophysical properties of materials.

Objectives:

At the end of the course, the student will have acquired knowledge of the thermodynamic analysis of reverse energy conversion systems applied to refrigeration and heating.

In particular, he/she will be able to identify energy flows, apply the mass and energy balance equations, define the main energy performance parameters and relate their variation to the boundary conditions and component sizing, for basic and advanced vapour compression cycles, for "gas liquefaction" cycles (Linde and Claude cycle), for absorption systems.

The student will be able to describe the operating principle and influencing parameters of the main technologies and components used in vapour compression cycles; he/she will be familiar with the environmental and safety regulations relating to the use of refrigerants.

The student will study basic elements of emerging technologies (solid state refrigeration).

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:

Oral exam

Course: REGOLAZIONE DELLE CENTRALI ELETTRICHE *ELECTRICAL POWER PLANT REGULATION*	**Teaching Language:** ITALIAN
SSD (SUBJECT AREAS): IIND-08/B (EX ING-IND/33)	**CREDITS:** 6
Course year: I	**Type of Educational Activity: C**

Teaching Methods:
In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:
The scientific disciplinary field is concerned with scientific and educational activity related to interconnected plants, networks and systems of components and apparatuses that use energy-significant electric carriers for production, transmission, distribution, distributed generation, storage and utilization of electric energy. This includes industrial electrical systems, smart grids, microgrids, energy communities, electric mobility and transportation systems, special electrical systems, lighting systems, building automation and home automation. Related to this context are the planning, design, implementation, management, supervision, control, and diagnostics of electrical systems, including materials, components, and technologies. Of particular interest are: reliability, resilience, quality, safety, electromagnetic compatibility, sustainability, interconnection of energy systems and integration of renewables, and electricity markets and economics. Methodologies and tools used include deterministic and probabilistic models, data analysis, simulation, experimentation, optimization, forecasting, ICT technologies, digitization, power electronics, automation, artificial intelligence, big data, and digital twin

Objectives:
The course focuses on the skills related to the control of power plants. Different typologies of power plants are investigated first, together with various configurations which typically characterize the plant electrical scheme. Then, regulation techniques for hydro and thermal power plants are analysed with reference to the speed control, which is strictly related to the power system frequency. Primary focus of the course is the identification of models needed for the dynamic analysis of the plant in case of load variation, faults, changes of renewable power generation and configuration of power system to which the plant is connected. Further objective of the course focuses on skills in designing regulators for primary and secondary frequency control service.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:
Oral

Course: SICUREZZA E MANUTENZIONE DEGLI IMPIANTI INDUSTRIALI *SAFETY AND MAINTENANCE OF INDUSTRIAL PLANTS*	**Teaching Language:** ITALIAN
SSD (SUBJECT AREAS): IIND-05/A (EX ING-IND/17)	**CREDITS**: 9
Course year: I	**Type of Educational Activity: D**

Teaching Methods:
In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:
The scientific disciplinary field studies with a systems approach the general criteria, methodologies and techniques that preside over the different phases of the life cycle of industrial systems understood as systems characterized by a high integration of plants, technologies, human resources and information. Of particular importance are the following strands of scientific and educational interest: -analysis and design of production systems for goods and services, including feasibility study, location selection, economic evaluation, and plant project management; -design of production processes and techniques, general plant services, and systems for energy production, recovery, and utilization; - layout planning; - study and design of manufacturing, remanufacturing, assembly, disassembly, recovery and recycling systems, through methods of analysis, simulation, optimization, control and performance evaluation with a view to sustainability; - ergonomic and safety design in production and service processes, risk assessment in workplaces, infrastructure and production processes; - management of production systems for goods and services including planning, scheduling, management and control of production, integrated management of quality, environment, energy and safety - life cycle management and maintenance of products, plant and equipment, production infrastructure and product-service systems, with particular reference to modeling reliability, durability, maintainability and availability; - integrated design and management of logistics systems and services; - automation of production systems, including cost-effectiveness analysis of integrated and flexible systems.

Objectives:
The objective of the course is the study of qualitative and numerical modelling techniques of the production reality according to good Safety and Maintenance practices; use of simulation methods to support relevant decision-making choices and assess their economic and production impact, as well as compliance with legal requirements, complete teaching. Furthermore, teaching aims at acquiring the specific vocabulary inherent to the course topics, mastering their transmission, both written and oral; structuring a safety and maintenance plan according to WCM principles; implementing and evaluating production costs in light of cost deployment criteria; and implementing an autonomous and professional maintenance plan.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:
Written and oral exam

Course: SISTEMI DI PROPULSIONE IBRIDI *HYBRID PROPULSION SYSTEMS*	**Teaching Language:** ITALIAN
SSD (SUBJECT AREAS): IIND-06/A (ex ING-IND/08)	**CREDITS:** 6
Course year: I	**Type of Educational Activity: B**

Teaching Methods:
In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:
The discipline covers the scientific and educational issues related to thermodynamic, fluid dynamic, aero-acoustic, aero-mechanic, energetic, technological, environmental and sustainability problems of all fluid machinery and fluid-based energy conversion systems. Of interest are the design, control, diagnostic, optimization, operation, testing, commissioning and environmental impact of fluid machinery and power systems (such as turbines, expanders, internal combustion engines possibly integrated into hybrid propulsion systems, fluid power systems), as well as fans, compressors and pumps. Likewise, devices involving chemical reactions (such as combustors, gasifier, reactors, fuel cells and reverse electrolysis systems) and heat transfer (such as evaporators, condensers and recuperators) are issues of relevance. Further, the integration of those machineries and devices into more complex systems aimed at the generation, conversion, storage, and distribution of electrical and thermal energy, as well as their usage for land, aerial and naval propulsion applications is of interest. Finally, process engineering and service applications are also envisaged.

Objectives:
The course aims to deepen the study of the latest generation of automotive propulsion systems, for a sustainable mobility from an energy and environmental point of view. With reference to propulsion systems for urban and extra-urban vehicle traction, the most recent methodologies available for the reduction of consumption and emissions will be studied in detail. The course provides an insight about the hybrid architecture of the propulsion systems, also considering their degree of electrification. The operating principle of the most important sub-components of hybrid propulsion system is presented (battery, electric motor/generator, internal combustion engine, fuel cell, gear box, transmission, etc.). The course will highlight the complex interactions among the different subsystems that constitute a modern propulsion system, in order to achieve specific objectives in terms of performance and fuel consumption. The guidelines for the identification of control strategies for energy management in hybrid propulsion systems (series, parallel and their various combinations) will be defined. The theoretical notions about the control and management of hybrid powertrains will be experienced with the support of numerical codes. Seminars will be held by staff from leading companies in the automotive sector, or from research centers.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:
Oral

Course:	**Teaching Language:**
SISTEMI ELETTRICI PER L'ENERGIA *ELECTRIC POWER SYSTEMS*	ITALIAN
SSD (SUBJECT AREAS):	**CREDITS:**
IIND-08/B (EX ING-IND/33)	9
Course year: I	**Type of Educational Activity: C**

Teaching Methods:

In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:

The scientific disciplinary field is concerned with scientific and educational activity related to interconnected plants, networks and systems of components and apparatuses that use energy-significant electric carriers for production, transmission, distribution, distributed generation, storage and utilization of electric energy. This includes industrial electrical systems, smart grids, microgrids, energy communities, electric mobility and transportation systems, special electrical systems, lighting systems, building automation and home automation. Related to this context are the planning, design, implementation, management, supervision, control, and diagnostics of electrical systems, including materials, components, and technologies. Of particular interest are: reliability, resilience, quality, safety, electromagnetic compatibility, sustainability, interconnection of energy systems and integration of renewables, and electricity markets and economics. Methodologies and tools used include deterministic and probabilistic models, data analysis, simulation, experimentation, optimization, forecasting, ICT technologies, digitization, power electronics, automation, artificial intelligence, big data, and digital twin

Objectives:

The course aims to deepen the following aspects related to electrical systems for energy. Electrical System: Regulation and Legislation. Regulatory bodies. General information on production, transmission, distribution electrical power systems. Three-phase systems. Transmission line theory: Introduction. Primary line constants. Telegrapher equations. Sinusoidal steady-state symmetrical three-phase lines. Notes on power flows issue in the transmission and distribution networks. Notes on voltage regulation issue. Definition of electrical system made in a workmanlike manner. Single-line grid diagram; Legislative framework of electrical installations; Project documentation. Utilization and contemporaneity factors. Load recognition for the sizing of electrical systems. Calculation of short-circuit currents. Notes on the state of the neutral. Coding of cables according to CEI- UNEL 35011. Types of laying. Criterion of maximum permissible voltage drop. Thermal criterion. Criterion of maximum economic gain. Difference between overload and short circuit conditions. Automatic switches and their tripping characteristics. Evaluation of maximum and minimum short-circuit current. Specific passing energy. Cable-switch coordination for short-circuit. Short circuit current components. Power cut-off. Electrical safety. TN and TT systems. Ground systems.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:

Oral

Course: SISTEMI ENERGETICI INNOVATIVI *INNOVATIVE ENERGY SYSTEMS*	**Teaching Language:** ITALIAN
SSD (SUBJECT AREAS): IIND-06/A (ex ING-IND/08)	**CREDITS:** 6
Course year: I or II	**Type of Educational Activity: B**

Teaching Methods:
In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:
The discipline covers the scientific and educational issues related to thermodynamic, fluid dynamic, aero-acoustic, aero-mechanic, energetic, technological, environmental and sustainability problems of all fluid machinery and fluid-based energy conversion systems. Of interest are the design, control, diagnostic, optimization, operation, testing, commissioning and environmental impact of fluid machinery and power systems (such as turbines, expanders, internal combustion engines possibly integrated into hybrid propulsion systems, fluid power systems), as well as fans, compressors and pumps. Likewise, devices involving chemical reactions (such as combustors, gasifier, reactors, fuel cells and reverse electrolysis systems) and heat transfer (such as evaporators, condensers and recuperators) are issues of relevance. Further, the integration of those machineries and devices into more complex systems aimed at the generation, conversion, storage, and distribution of electrical and thermal energy, as well as their usage for land, aerial and naval propulsion applications is of interest. Finally, process engineering and service applications are also envisaged.

Objectives:
The course aims to deepen the study of the latest generation thermal engine systems with a low environmental impact and renewable energy systems. The study of power systems for the electricity production and for propulsion both of the conventional type and in hybrid configuration will be tackled. With reference to electricity production systems, the most recent methodologies available for the reduction of consumption and pollutant emissions, as well as carbon dioxide, will be studied in detail. To this end, in addition to traditional thermal plants, renewable plants such as solar thermodynamic plants, hydroelectric plants, geothermal plants and energy storage systems will be studied. Fuel cells with its applications and ORC systems (Organic Rankine Cycle) will be studied. The study of innovative combustion systems will be tackled and their impact on the production of pollutant emissions. The study of innovative fuels (syngas) derived from biomass gasification, carbon (IGCC System) or reforming and mixtures with hydrogen will then be addressed. The power systems will be examined in cogeneration and integrated with a solar field and / or ORC systems. The study of mixed gas / steam cycles (STIG, RWI, HAT) and combined cycles will be addressed. References of the operating principle of internal combustion engines (ICE), deepening the study of the common rail diesel engine fueled with diesel and in dual fuel mode (diesel-methane); the spark ignition engine with indirect (PFI) and direct injection (GDI) system. Particular attention will be paid to pollutant emissions from ICE and abatement methods. Hybrid propulsion system (HEV) for applications on vehicles and aircraft will be presented.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:
Oral

Course: SMART AND ELECTRIC MOBILITY *MOBILITÀ INTELLIGENTE ED ELETTRICA*	**Teaching Language:** ENGLISH
SSD (SUBJECT AREAS): CEAR-03/B (EX ICAR/05)	**CREDITS:** 9
Course year: I or II	**Type of Educational Activity: D**

Teaching Methods:

In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:

The contents of the scientific disciplinary field concern the understanding of the phenomena of mobility of persons and transport of goods, knowledge of methods and models for the analysis and simulation, design and planning, management and operation of individual and collective transport systems, including organizational and technological aspects, evaluation of the performance and impacts of transport policies. Of interest, at the various geographic scales and spatial levels, are land, air, and waterborne transportation, aspects of technological innovation and safety, travel behavior including with reference to the circular and sharing economy, mobility as a service, and aspects related to the transportation and logistics market. Applications include decision-support tools for sizing, optimization, including in emergencies, of facilities, infrastructure, networks, and services to improve accessibility, performance, and pursue energy, environmental, economic, and social sustainability; smart, safe, and inclusive transportation infrastructure and systems; cooperative, connected, and automated mobility

Objectives:

The objective of the course is to provide the student with knowledge and operational tools for the analysis, functional design and evaluation of the impacts of electric mobility and new shared mobility services in urban settings.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:

The exam includes an oral test and the discussion of a project paper

Course:	**Teaching Language:**
SMART, RESILIENT AND SUSTAINABLE CITY *CITTÀ INTELLIGENTE, RESILIENTE E SOSTENIBILE*	ENGLISH

SSD (SUBJECT AREAS):	**CREDITS:**
CEAR-01/B (EX ICAR/02)	9

Course year: I or II	**Type of Educational Activity: D**

Teaching Methods:

In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:

The scientific disciplinary field develops water cycle issues in relation to the design, construction, and operation of civil works and infrastructure and the design of sustainable strategies for soil and coastal defense, environmental protection, water resources management, and adaptation to climatic and environmental variations. Deals with theoretical and applied aspects of hydrological science and water engineering, with reference to: meeting water needs; protection of people, the man-made and natural environment from floods, drought, storm surges, water-triggered flows and landslides, pollutants and pathogens in surface and groundwater; interactions with the atmosphere and ecosystems. Application domains include monitoring and modeling of hydrological processes; infrastructure for storage, regulation, adduction, distribution, drainage, and energy production; control and monitoring of water in urban, agricultural, and industrial settings; waterways; and maritime, river, slope, and coastal works, within a vision of integrated hydraulic and hydrological risk management

Objectives:

The aim of teaching is the integration of approaches to the study of city safety, understood as a dynamic and complex spatial system, which allows identifying a panel of sustainable actions capable of reducing the risk levels at which urban systems are currently exposed. Urban resilience is connected to the possibility that the city, in the face of one or more external agents, is able to counteract an opposite reaction (resilient), safeguarding the safety of the inhabitants, maintaining its own levels of organization, protecting the stock existing building, allowing the continuation of existing activities.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:

Oral interview on the main topics and discussion of the exercises. There are no written tests, there are no elapsed tests. The final evaluation is single and is expressed out of thirty based on the following criteria:

- Knowledge and understanding
- Applying knowledge and understanding
- Making judgments
- Communication skills
- Learning skills

Course: SPACE PROPULSION *PROPULSIONE SPAZIALE*	**Teaching Language:** ENGLISH
SSD (SUBJECT AREAS): IIND-01/G (EX ING-IND/07)	**CREDITS:** 9
Course year: I	**Type of Educational Activity: D**

Teaching Methods:

In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:

The scientific disciplinary field covers the scientific and educational/training aspects related to aerospace, transatmospheric and space propulsion, starting from the phenomena governing the operation of the individual thruster component to the multidisciplinary integration with other aspects of aerospace vehicle design conceived as a "system of systems" with particular attention to environmental impact, sustainability, airmobility and space economy.

The disciplines in the field study: the theoretical, numerical and experimental methodologies involved in the design, development and realization of aerospace thrusters; the fundamental principles and engineering applications of the thermo-chemical-physical processes involved in the operation of aerospace thrusters; performance evaluation; technological and plant engineering aspects; employment criteria; and measurement and experimental techniques.

Objectives:

The course covers the fundamentals of rocket propulsion and discusses advanced concepts in space propulsion ranging from chemical to electric motors, for launch, orbital and interplanetary flight. Topics include analysis of requirements for typical space missions, physics and engineering of chemical thrusters (solid, liquid, hybrid, monopropellant bipropellant rockets), hypersonic air-breathing engines, and electric thrusters, including electrothermal thrusters, electrostatic and electromagnetic. Physical and chemical modeling as well as design and technological issues will be discussed.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:

Oral

Course: SPERIMENTAZIONE ED IMPATTO AMBIENTALE DELLE MACCHINE *MEASUREMENTS AND ENVIRONMENTAL IMPACT OF MACHINERY*	**Teaching Language:** ITALIAN
SSD (SUBJECT AREAS): IIND-06/B (EX ING-IND/09)	**CREDITS:** 9
Course year: II	**Type of Educational Activity: B**

Teaching Methods:

In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:

The discipline covers the energy conversion systems from conventional sources (fossil fuels and nuclear reactor fuels) and renewable ones (solar, wind, hydro and tidal, geothermal, from biomass and solid wastes). Of interest are the production and usage of alternative fuels, driving systems, thermal plants, heat and refrigeration pumps, as well as the fluid-based energy systems, the energy transportation process, the energy recovery and storage systems, and their role inside smart grids. Likewise, fluid power components and devices finalized at direct energy conversion process are of relevance. The scientific and educational aspects of the above-mentioned energy systems and of the related machineries deal with thermodynamic, fluid-dynamic, technology, safety, diagnostic and control issues, with a particular focus on the environmental impact and on the technologies specifically designed for their mitigation or abatement. Those aspects are analyzed in an energy planning context at several scales not disregarding the sustainability of the various process, systems and components within their life cycle.

Objectives:

The course provides the basic knowledge on the main applications of the measures applied to fluid machinery with particular attention to the experimental evaluation of machines performance and pollutant emission; furthermore, the basic knowledge for the realization of a complete data acquisition system are provided. It also provides knowledge on the issues of environmental control regarding air quality. The environmental regulations and the current control systems are being studied. Finally, are provided several tools for proper environmental planning with reference to the pollutant emissions of fluid machines and energy-production systems.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:

Written / Oral

Course:	**Teaching Language:**
SUSTAINABLE COMBUSTION PROCESSES FOR ENERGY CONVERSION *PROCESSI DI COMBUSTIONE SOSTENIBILI PER LA CONVERSIONE DELL'ENERGIA*	ENGLISH

SSD (SUBJECT AREAS):	**CREDITS:**
ICHI-02/A (ex ING-IND/25)	9

Course year: I	**Type of Educational Activity: C**

Teaching Methods:

In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:

The scientific discipline includes the study of methodologies for the design, realization, verification and operation of industrial plants based on chemical-physical and biological transformations of matter aimed at the production of goods, the provision of services and the prevention or mitigation of modifications to the environment induced by human activities or settlements. Qualifying for the field, in both scientific and didactic-training activities, are: plant design including simulation, elaboration of quantified process and functional schemes including protection and control instrumentation; selection, design, prototyping and verification of reactors and equipment for unit operations and development of related experimental methodologies; safety and risk analysis of plants and processes; and economic, sustainability and environmental impact assessments also examined in the context of industrial ecology. Areas of focus are chemical, pharmaceutical, food, energy, extraction, refining, transport and storage technologies for raw materials and energy carriers; biotechnology; and technologies supporting environmental protection and the circular economy.

Objectives:

The course aims to provide the methodological tools and knowledge to frame combustion processes in the context of energy conversion and power generation applications in order to assess their potential development under the constraints related to sustainability and the use of alternative energy carriers for decarbonization. In addition, the course defines the most relevant prototype configurations and equations describing combustion processes evolving under fixed boundary/initial conditions, analyzing their most significant parameters and most sensitive variations. This systematic framing of combustion processes enables the enucleation of the most significant sub-processes that can be addressed by established computational methods of a multidisciplinary nature. Finally, the course analyzes specific categories of combustion processes with the aim of using the acquired methodological tools, to familiarize with simple processes design, and to develop critical paths that allow new configurations to be considered in their potentialities and similarities with established configurations. Finally, the main mechanisms of formation and abatement of the main pollutants are analyzed according to the peculiarities related to the energy vector used.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:

Oral exam and group exercises.

Course: SUSTAINABLE MATERIALS *MATERIALI SOSTENIBILI*	**Teaching Language:** ENGLISH
SSD (SUBJECT AREAS): IMAT-01/A (EX ING-IND/22)	**CREDITS:** 6
Course year: I or II	**Type of Educational Activity: C, D**

Teaching Methods:
In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:
The scientific disciplinary field is concerned with scientific and educational activity in the field of Materials Science and Technology and in particular encompasses the body of knowledge related to materials, both structural and functional, having technical and engineering interest. Strongly characterizing the field is the study of the link between the structural, microstructural, and functional properties of materials and their macroscopic properties, performance, and transformation and production processes. More specifically, the field studies: - the relationships between the structure of materials at all dimensional scales (from nano to macro), formulation, design, properties (chemical, biochemical, physical, mechanical, surface, and biocompatibility), and performance; - traditional and innovative technologies of materials production, processing, and transformation, as well as those related to analysis, characterization, and quality control; hybrid system interfaces, surface treatments with and without material input, and the set of methodologies, techniques, and treatments for functionalization; - methodologies and processes for contextual fabrication of the material and component; - in-service behavior, durability, corrosion and wear resistance, degradation, preservation, restoration, protection technologies, environmental protection and sustainability technologies, reuse and recycling with material and energy recovery, and life cycle analysis. The field deals with metallic materials and their alloys, ceramic materials and glasses, polymeric materials and plastics, cementitious materials and binders, semiconductors, biomaterials, the multimaterial combinations and composites, both natural and man-made. Teaching activities cover the disciplines, both basic and specialized, typical of engineering and materials science and technology.

Objectives:
The course aims to provide students with advanced information on the sustainability of materials and environmental impact assessment. The principles of sustainability and sustainable development will be introduced, as well as their application to the production and processing strategies of materials. The criticality of currently available resources will be explored, as well as the opportunity to recycle materials. Finally, different methods for assessing sustainability will be presented and studied, along with a series of case studies.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:
Oral, project discussion

Course: TECHNOLOGIES FOR INFORMATION SYSTEMS *TECNOLOGIE PER I SISTEMI INFORMATIVI*	**Teaching Language:** ENGLISH
SSD (SUBJECT AREAS): IINF-05/A (EX ING-INF/05)	**CREDITS:** 9
Course year: I or II	**Type of Educational Activity: D**

Teaching Methods:
In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:

The scientific disciplinary group covers scientific and educational activity in the field of Computer Engineering. The competencies of the group cover models, methodologies, principles and techniques specific to the analysis, design, development and conduct of information systems. This also applies with reference to multidisciplinary areas such as digital humanities, smart mobility, cultural heritage, e-health, smart cities, e-government, legal informatics, and smart manufacturing. The group covers research topics that can be organized into the following research domains: - Computing system architectures, which includes embedded, real-time and cyber-physical systems, architectures for energy-efficient, high-performance and quantum computing, tools for modeling, simulation, and automatic design of digital systems; - Distributed and parallel systems, which includes operating systems, computer networks, computing aspects of IoT, cloud-edge systems, and performance evaluation tools; - software engineering: includes methodologies, programming languages, software infrastructures and related tools; - algorithm engineering and theoretical computer science, which includes computational complexity, distributed, parallel, on graphs, quantum algorithms, algorithmic game theory, formal methods and computational models; - computer security, which includes computing techniques for cybersecurity and privacy, cryptography and computer network security; - artificial intelligence, which includes autonomous and intelligent robotics, intelligent systems, knowledge engineering and natural language processing; - graphics, computer vision and multimedia: includes image, video and sound processing, computer games and virtual reality; - human-computer interaction, which includes user-centered design, quality of user experience and information visualization; - databases and information systems, which includes Web technologies, information retrieval, digital libraries, data transformation and integration, Big Data and data management in bioinformatics; - machine learning, which includes data mining, process mining, computer aspects of data science and signal processing and recognition techniques, sensory data processing in robotics, and biological and biomedical data analysis. Teaching activities cover the spectrum from the various specialized domains to basic training in the use, in all fields, of methodological and technological approaches specific to computer engineering. Theoretical foundations, methods, and technologies for defining requirements, designing, developing, evaluating, and managing computer systems, ensuring their adequacy, correctness, reliability, performance, security, cost-effectiveness, sustainability, and ethical compliance fall within the scope of the group

Objectives:
Students will go deep into Information Systems Technology with a special focus on BI and Big Data topics thus acquiring fundamental skills for future career.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:
Project, Written and oral exam

Course:	**Teaching Language:**
TECNICHE E MODELLI PER LA REFRIGERAZIONE *TECHNIQUES AND MODELS FOR REFRIGERATION*	ITALIAN

SSD (SUBJECT AREAS):	**CREDITS:**
IIND-07/A (EX ING-IND/10)	9

Course year: II	**Type of Educational Activity: B**

Teaching Methods:

In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:

The group includes skills relating to the following topics: thermodynamic, thermokinetic analysis of energy processes and their environmental impact, principles, methodologies and technologies for sustainable energy conversion from renewable and conventional energy sources, final uses of energy, energy management, techniques for monitoring and processing energy data and models, energy efficiency technologies and applications, thermoeconomics, technologies for the energy transition, physics of the built environment, with particular reference to the interaction among occupants and the environment, thermophysics of buildings, technical plants for civil applications, energy diagnosis and optimization of the building-plant-territory system, applied acoustics, lighting engineering, air quality, passive systems and plant technologies for air conditioning and environmental well-being. It also studies thermo-fluid-dynamic phenomena in biological and agri-food systems, refrigeration technologies, thermotechnics, heat exchange and energy storage systems and components, fire safety, thermophysical properties of materials, measurements and thermo-fluid-dynamic controls, materials for energy, acoustics and lighting engineering.

Objectives:

As regards vapor compression systems, to provide thermodynamic and technical knowledge aimed at the choice of the plant layout, components and their correct design, with respect to the specific user requirements, such as industrial or commercial refrigeration and air conditioning. Particularly, thermodynamic aspects related to working fluids, the effect of the refrigerant charge, the degrees of freedom for control purposes, the influence of the operating conditions on the system performance map, the determination of the working condition by matching between user/plant systems, are all deepened. To describe the working principle to recognize technical limitations and the optimal choice for each component, with respect to the specific application. To model and calibrate single components, by means of ad-hoc software and information from datasheets or real case studies. To successfully employ and run these models, for an optimized design and the energetic simulation of the system for the evaluation of the seasonal performance according to the ongoing Regulations. To deepen the thermodynamics of reverse gas cycles, absorption cycles and cycles for liquefaction of gases. To introduce the current issues and related innovations in the refrigeration field.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:

Project work and oral

Course: TECNOLOGIE AVANZATE PER L'ENERGIA *ADVANCED ENERGY TECHNOLOGIES*	**Teaching Language:** ITALIAN
SSD (SUBJECT AREAS): IIND-07/A (EX ING-IND/10)	**CREDITS:** 6
Course year: II	**Type of Educational Activity: B**

Teaching Methods:
In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:
The group includes skills relating to the following topics: thermodynamic, thermokinetic analysis of energy processes and their environmental impact, principles, methodologies and technologies for sustainable energy conversion from renewable and conventional energy sources, final uses of energy, energy management, techniques for monitoring and processing energy data and models, energy efficiency technologies and applications, thermoeconomics, technologies for the energy transition, physics of the built environment, with particular reference to the interaction among occupants and the environment, thermophysics of buildings, technical plants for civil applications, energy diagnosis and optimization of the building-plant-territory system, applied acoustics, lighting engineering, air quality, passive systems and plant technologies for air conditioning and environmental well-being. It also studies thermo-fluid-dynamic phenomena in biological and agri-food systems, refrigeration technologies, thermotechnics, heat exchange and energy storage systems and components, fire safety, thermophysical properties of materials, measurements and thermo-fluid-dynamic controls, materials for energy, acoustics and lighting engineering.

Objectives:
The course is of fundamental importance for engineers involved in energy efficiency systems and innovative energy design, and it aims at developing knowledge on advanced energy technologies towards sustainability. The basic knowledge relative to actions and measures to achieve energy saving through the design of advanced energy systems based on renewable energy source are explored. To this goal, the use of dynamic simulation and systems optimization is proposed. The student, at the end of the learning process, will be able to:
1. select the proper innovative energy technologies, depending on the use and the objective to be achieved in terms of energy efficiency and economic feasibility;
2. perform, through the use of specific simulation software, the dynamic analysis of the energy, economic and environmental performance of the proposed and investigated systems made of diverse technologies;
3. carry out the preliminary design of the proposed systems through the optimization of the relative main design and operating parameters through different function objectives (maximum savings, minimum climate-altering emissions, minimum payback period).

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:
Oral and project discussion

Course: TECNOLOGIE SPECIALI *NON-CONVENTIONAL MANUFACTURING TECHNOLOGIES*	**Teaching Language:** ITALIAN
SSD (SUBJECT AREAS): IIND-04/A (EX ING-IND/16)	**CREDITS:** 9
Course year: I	**Type of Educational Activity: D**

Teaching Methods:
In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:
The scientific and didactic-training activities of the scientific disciplinary field refer to the field of manufacturing technologies and systems. The activities concern manufacturing processes, transformation and management of materials in relation to the entire life cycle of products from their conception, production, reuse or recycling according to circular economy strategies. In particular, the field studies and takes care of the teaching of the following elements also considering the intersections between scientific, technological, economic and sustainability aspects: - the mechanical, technological, functional and structural characterization of materials to define the link of their properties with the parameters governing the processes. - the transformation processes, at all dimensional scales, affecting productions, from manufacturing with additive, subtractive and invariant techniques, to joints and assemblies, to deproduction according to circular economy strategies. - the methodologies and tools for: the design of processes, components and processing systems and the characterization of their performance in terms of precision, efficiency, cost and suitability for use, from an integrated and sustainable perspective; ; planning, management, control, and quality improvement of products and processes; product development with a view to sustainability and reduction of production costs and time; reverse engineering, industrial metrology applied to production, testing of products, equipment, and production systems; and management of energy conservation and protection of the environment and the mental and physical well-being of operators

Objectives:
The aim of the course is to provide students with in-depth knowledge on light and medium-light metal alloys of industrial interest and of the main unconventional manufacturing processes for metals, in order to allow students to acquire knowledge on the complex thermal, chemical and mechanical mechanisms occurring in the transformation processes and link these to the performance of the manufactured products and finally provide students the fundamentals for a critical and conscious choice of the most appropriate technological process for the production of parts, balancing the economic, performance and technological aspects involved.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:
Oral

Course: TERMOFLUIDODINAMICA COMPUTAZIONALE *COMPUTATIONAL THERMAL-FLUID-DYNAMIC*	**Teaching Language:** ITALIAN
SSD (SUBJECT AREAS): IIND-07/A (EX ING-IND/10)	**CREDITS:** 9
Course year: I or II	**Type of Educational Activity: B**

Teaching Methods:
In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:
The group includes skills relating to the following topics: thermodynamic, thermokinetic analysis of energy processes and their environmental impact, principles, methodologies and technologies for sustainable energy conversion from renewable and conventional energy sources, final uses of energy, energy management, techniques for monitoring and processing energy data and models, energy efficiency technologies and applications, thermoeconomics, technologies for the energy transition, physics of the built environment, with particular reference to the interaction among occupants and the environment, thermophysics of buildings, technical plants for civil applications, energy diagnosis and optimization of the building-plant-territory system, applied acoustics, lighting engineering, air quality, passive systems and plant technologies for air conditioning and environmental well-being. It also studies thermo-fluid-dynamic phenomena in biological and agri-food systems, refrigeration technologies, thermotechnics, heat exchange and energy storage systems and components, fire safety, thermophysical properties of materials, measurements and thermo-fluid-dynamic controls, materials for energy, acoustics and lighting engineering.

Objectives:
The course aims at providing students with the advanced, theoretical and practical, elements, to allow a conscious use of the techniques of Computational Thermo-Fluid Dynamics in the application and industrial field. The student will acquire the knowledge of various methods for the numerical resolution of the equations of conservation of mass, momentum and energy and of various software for thermo-fluid dynamics design in the field of mechanical engineering. Some theoretical aspects, such as dimensional analysis, and experimental aspects, such as similarity and related models, of fundamental importance for the development and validation of the models themselves, will be exposed. At the end of the course, students will be able to reconcile the two aspects of Computational Thermo-Fluid Dynamics –theoretical foundations and application methods –which are often treated separately.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:
Numerical project and oral

Course: TERMOFLUIDODINAMICA DELLE MACCHINE *AERO-THERMODYNAMICS OF FLUID MACHINERY*	**Teaching Language:** ITALIAN
SSD (SUBJECT AREAS): IIND-06/A (ex ING-IND/08)	**CREDITS:** 9
Course year: I	**Type of Educational Activity: B**
Teaching Methods: In person	
Contents extracted from the SSD declaratory consistent with the training objectives of the course: The discipline covers the scientific and educational issues related to thermodynamic, fluid dynamic […] problems of all fluid machinery and fluid-based energy conversion systems. Of interest are the design, […], optimization, operation, testing […] of fluid machinery and power systems (such as turbines […]), as well as fans, compressors and pumps. […].	
Objectives: The purpose of the course is to provide the basic tools required to analyse the operating principles of fluid machinery, and mainly those installed in energy conversion systems for power generation. The course deals with the fundamentals of thermo-fluid-dynamics of machines discussing many practical applications. Attention is also paid to the most relevant problems associated with the operation and selection of fluid machinery.	
Propaedeuticities: **Is a propaedeuticity for:**	
Types of examinations and other tests: Oral	

Course:	**Teaching Language:**
THERMO-ECONOMIC OPTIMIZATION OF COMPLEX ENERGY SYSTEMS *OTTIMIZZAZIONE TERMOECONOMICA DI SISTEMI ENERGETICI COMPLESSI*	ENGLISH
SSD (SUBJECT AREAS): IIND-07/A (EX ING-IND/10)	**CREDITS:** 6
Course year: II	**Type of Educational Activity: B**

Teaching Methods:

In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:

The group includes skills relating to the following topics: thermodynamic, thermokinetic analysis of energy processes and their environmental impact, principles, methodologies and technologies for sustainable energy conversion from renewable and conventional energy sources, final uses of energy, energy management, techniques for monitoring and processing energy data and models, energy efficiency technologies and applications, thermoeconomics, technologies for the energy transition, physics of the built environment, with particular reference to the interaction among occupants and the environment.

Objectives:

The objective of the course is to provide the students with a background in the analysis, design, and optimization of complex energy systems and their operation using mathematical programming and multi-objective approaches. The course focuses on a comprehensive evaluation of the methodologies and processes for optimization of complex energy systems from polygeneration systems to integrated energy networks with multiple energy carriers. The covered sectors for the integration of emerging technologies are electricity, heating, cooling, hydrogen and mobility, with emphasis on sustainable solutions and renewable energy sources. The optimization of energy systems will be considered at three levels: synthesis, design, and operation (SDO). Synthesis optimization tackles the problem of finding the optimum configuration of a system (number, type, and functional interconnections of the components installed). In design optimization, the optimal capacity of the components is determined, while operation optimization determines the optimal operation strategies of the system on a daily basis. Different types of analysis will be emphasized, such as energy, economic, and environmental optimization, which will be treated through a multi-objective approach (Pareto frontier analysis). The course will provide the mathematical formulation of the different types of energy systems problems, the solution methods, and their implementation through dedicated optimization codes. This optimization aims at the medium- and long-term sustainability of the energy supply, distribution, and use in the residential and industrial sectors. Students will gain knowledge about planning and operation of complex energy systems through different case studies, considering multiple users and related multi-energy requirements, different energy carriers, and different scenarios related to energy costs and renewable energy penetration levels, with the aim to apply the optimization techniques to a project work.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:

Oral exam with a work project.

Course:	**Teaching Language:**
THERMO-MECHANICAL TECHNOLOGIES FOR ENERGY TRANSITION *TECNOLOGIE TERMO-MECCANICHE PER LA TRANSIZIONE ENERGETICA*	ENGLISH
SSD (SUBJECT AREAS):	**CREDITS:**
IIND-06/B (EX ING-IND/09) - IIND-07/A (EX ING-IND/10)	6
Course year: II	**Type of Educational Activity: B**

Teaching Methods:

In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:

The discipline covers the energy conversion systems from conventional sources (fossil fuels and nuclear reactor fuels) and renewable ones (solar, wind, hydro and tidal, geothermal, from biomass and solid wastes). Of interest are the production and usage of alternative fuels, driving systems, thermal plants, heat and refrigeration pumps, as well as the fluid-based energy systems, the energy transportation process, the energy recovery and storage systems, and their role inside smart grids. Likewise, fluid power components and devices finalized at direct energy conversion process are of relevance. The scientific and educational aspects of the above-mentioned energy systems and of the related machineries deal with thermodynamic, fluid-dynamic, technology, safety, diagnostic and control issues, with a particular focus on the environmental impact and on the technologies specifically designed for their mitigation or abatement. Those aspects are analyzed in an energy planning context at several scales not disregarding the sustainability of the various process, systems and components within their life cycle.

Objectives:

The sustainability of the base processes. Energy efficiency enhancement and reliable renewable sources exploitation will play a key role in the transition towards a zero-carbon society. The course offers an overview of the most advanced thermo-mechanical technologies accompanying the ongoing energy transition, in the following fields: renewable heating and cooling, heat recovery and heat integration in industrial processes, thermal and mechanical energy storage systems, polygeneration and multi-energy systems, production, storage and utilization of hydrogen. Methodologies and criteria are assessed and discussed in detail to qualify those systems from technical, economic and environmental viewpoints. The resulting energy conversion strategy will help promoting a smooth transition towards a new energy model for long-term value and resilience.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:

Oral

Course: TRASMISSIONE DEL CALORE *HEAT TRANSFER*	**Teaching Language:** ITALIAN
SSD (SUBJECT AREAS): IIND-07/A (EX ING-IND/10)	**CREDITS:** 9
Course year: I	**Type of Educational Activity: B**

Teaching Methods:

In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:

The group includes skills relating to the following topics: thermodynamic, thermokinetic analysis of energy processes and their environmental impact, principles, methodologies and technologies for sustainable energy conversion from renewable and conventional energy sources, final uses of energy, energy management, techniques for monitoring and processing energy data and models, energy efficiency technologies and applications, thermoeconomics, technologies for the energy transition, physics of the built environment, with particular reference to the interaction among occupants and the environment, thermophysics of buildings, technical plants for civil applications, energy diagnosis and optimization of the building-plant-territory system, applied acoustics, lighting engineering, air quality, passive systems and plant technologies for air conditioning and environmental well-being. It also studies thermo-fluid-dynamic phenomena in biological and agri-food systems, refrigeration technologies, thermotechnics, heat exchange and energy storage systems and components, fire safety, thermophysical properties of materials, measurements and thermo-fluid-dynamic controls, materials for energy, acoustics and lighting engineering

Objectives:

The course provides fundamentals and methods to study heat transfer. Course objectives consists in: teaching heat transfer fundamentals and laws to apply these to solve practical engineering problems, developing model necessary to study, analyze and design heat transfer devices, solving heat transfer problems by means of instruments and techniques typical of a wide technical education.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:

Written and oral exam

Course: TRIBOLOGIA E DIAGNOSTICA DEI SISTEMI MECCANICI *TRIBOLOGY AND DIAGNOSTIC OF MECHANICAL SYSTEMS*	**Teaching Language:** ITALIAN
SSD (SUBJECT AREAS): IIND-02/A (EX ING-IND/13)	**CREDITS:** 9
Course year: I	**Type of Educational Activity: D**

Teaching Methods:
In person

Contents extracted from the SSD declaratory consistent with the training objectives of the course:
The scientific disciplinary field is concerned with scientific and educational activity in the field of Applied Mechanics of Machines. It includes the cultural, scientific, professional and historical aspects inherent in the study of mechanical systems, machines, their components and structures. The study is approached, with a unifying systems approach, through the methodologies proper to theoretical, applied and experimental mechanics, leading to technological and industrial application, with attention to environmental and energy sustainability. The typology of mechanical systems considered is entirely general: driving and operating machines, mechanical and mechatronic devices, mechanisms, transmissions and drives, automatic machines and robotic systems, vehicles, conventional and autonomous transportation systems, lifting systems, energy production systems, biomechanical systems, and micro- and nano-scale components and systems. The field uses experimental, modeling and simulation methods for the analysis of mechanical behavior, functional design of machines and mechanical systems. Methods and applications are based on the study of kinematics, statics, dynamics, linear and nonlinear, interactions with the environment in general and between material surfaces (contact mechanics), control, automation and identification of mechanical systems. Interests in the field also include vibratory, vibroacoustic and tribological phenomena, mechatronics, fluid-structure interactions, monitoring, diagnostics and prognostics of mechanical systems, fluid automation and robotics, fluidics and microfluidics, and functional biomechanics. Implementation through hardware and software systems of the developed methods is an integral part of the knowledge of the field

Objectives:
The learning goal is to cover issues related to mechanical organ behavior, including mechanical organ size and lubrication. In addition, the course provides notions on monitoring and diagnostics of mechanical components using innovative techniques based on the application of the Wavelet Transform and Chaos Theory, and the study of complex systems.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:
Oral

Course: TURBOMACCHINE PER L'ENERGIA EOLICA *TURBOMACHINERY FOR WIND ENERGY*	**Teaching Language:** ITALIAN
SSD (SUBJECT AREAS): IIND-06/A (ex ING-IND/08)	**CREDITS:** 6
Course year: II	**Type of Educational Activity: B**
Teaching Methods: In person	
Contents extracted from the SSD declaratory consistent with the training objectives of the course: The discipline covers the scientific and educational issues related to […] fluid dynamic […], energetic, […] problems of all fluid machinery and fluid-based energy conversion systems. Of interest are the design, control, […] optimization, operation, testing […] of fluid machinery and power systems (such as turbines […]) […].	
Objectives: The course covers the most relevant aspects of wind turbines aerodynamics. The emphasis is on the performance analysis, operation, siting, selection and aerodynamic design of wind turbines.	
Propaedeuticities: **Is a propaedeuticity for:**	
Types of examinations and other tests: Oral, project discussion	

ANNEX 2.2

DEGREE PROGRAM DIDACTIC REGULATIONS

MECHANICAL ENGINEERING FOR ENERGY AND ENVIRONMENT

CLASS LM-33

School: Polytechnical and Basic Sciences

Department: Industrial Engineering

Didactic Regulations in force since the academic year 2025-2026

<table>
<tr><td colspan="2">Training Activity:
under Art. 10, c. 5, letter d</td><td>Training Activity Language:
ITALIAN / ENGLISH</td></tr>
<tr><td colspan="2">Content of the activities consistent with the training objectives of the course:
• Traineeship and internship, classified as:
  ○ Intramoenia
  ○ Extramoenia
• Other knowledges, among which:
  ○ Additional language skills
  ○ IT and telematics skills
  ○ Other knowledge useful for job placement</td><td>CFU:
• Internship: 9
• Other knowledges: 3</td></tr>
<tr><td colspan="2">Course year: I and II</td><td>Type of Training Activity: E, F</td></tr>
<tr><td colspan="3">Teaching Methods:
in-person / by distance teaching</td></tr>
<tr><td colspan="3">Objectives:
Those activities have the objective of giving to the student the ability to communicate correctly (also in English) in the technical-scientific field, to use the relevant scientific literature profitably and to acquire new knowledge and methodologies (including IT) during the development of one professional activity. They therefore contribute to the achievement of linguistic, IT and professional training objectives for the world of work.</td></tr>
<tr><td colspan="3">Propaedeuticities:

Is a propaedeuticity for:</td></tr>
<tr><td colspan="3">Types of examinations and other tests:
• Internship: aptitude
• Other knowledges: aptitude</td></tr>
</table>

ANNEX 3

DIDACTIC REGULATIONS OF THE MINOR

IN "GREEN TECHNOLOGIES"

Regulations in force since the academic year 2024-2025

ACRONYMS

CCD	[Commissione di Coordinamento Didattico]	Didactic Coordination Commission
CdS	[Corso/i di Studio]	Degree Program
CFU	[Crediti Formativi Universitari = 1 ECTS]	University training credits
CPDS	[Commissione Paritetica Docenti-Studenti]	Joint Teachers-Students Committee
OFA	[Obblighi formativi aggiuntivi]	Additional Training Obbligations
SUA-CdS	[Scheda Unica Annuale del Corso di Studio]	Annual single form of the Degree Program
RDA	[Regolamento Didattico di Ateneo]	University Didactic Regulations
PM	[Percorso Minor]	Minor

INDEX

Art. 1
Object

1. These Rules govern the organisational aspects of the Minor (PM) named "Green Technologies" (pursuant to Art. 3.3, 18.1 and 18.2 of the RDA)
2. The PM in Green Technologies is offered by the following Departments within the listed MSc courses.

PROPOSING DEPARTMENTS	
DEPARTMENT OF CHEMICAL, MATERIALS AND PRODUCTION ENGINEERING	MSc in Chemical Engineering (LM-22)
	MSc in Materials Engineering (LM-53)
DEPARTMENT OF ELECTRICAL ENGINEERING AND INFORMATION TECHNOLOGY	MSc in Electrical Engineering (LM-28)
DEPARTMENT OF INDUSTRIAL ENGINEERING	MSc in Mechanical Engineering for Energy and Environment (LM-33)
DEPARTMENT OF CIVIL, CONSTRUCTION AND ENVIRONMENTAL ENGINEERING	MSc in Environmental and Territorial Engineering (LM-35)

3. The PM in Green Technologies is supported by a Coordination Committee, hereinafter referred to as the 'Committee', consisting of the Coordinators of the proposing Study Courses or their delegates.
4. The Committee performs the following functions:
   - coordinates training activities;
   - verifies and takes decisions on PM students (verification of applications, admission or disqualification from PM, allocation of training plans);
   - supervises the general teaching organisation of the PM, in close liaison with the Departments and CCD of the CdS with which the PM is associated;
   - carries out periodic monitoring and verification of results, submitting its assessments to the Departments and CCD of the CdS with which the PM is associated, for the purpose of quality assurance of the CdS.
5. The members of the Committee designate among its members a Committee Coordinator, hereinafter referred to as the "PM Coordinator". The PM Coordinator is responsible for the functioning of the Committee and convenes its meetings.
6. The administrative management of the PM is entrusted to the PM Coordinator's department.
7. The Table of PM Training Activities is attached to these Regulations.

Art. 2
Knowledge and Skills of the Minor Pathway

Globalisation, the digital transition, the new centrality of sustainability issues, and the health emergency are affecting the world of professions and intellectual activities with an unprecedented urgency, requiring timely and reliable solutions to problems characterised by a high degree of complexity and multidimensionality. Professionals working in these areas are required to have an interdisciplinary approach and systemic vision in addition to their specific disciplinary training.
The University of Naples Federico II, which is very attentive to the needs for higher education posed by society, promotes a series of initiatives for the training of versatile professionals to be employed in strategic sectors, among which the **Minor in *Green Technologies*** finds a specific place.
The PM of the University of Naples Federico II responds to the aim of developing, starting from solid 'fundamentals' in the relevant engineering disciplines, professionals with systemic skills, interdisciplinary vision, digital skills, attentive to innovation, able to face the transformations accompanying the Ecological Transition with adequate cultural tools.
The training is developed through interdisciplinary teaching modules and project work activities, typically developed in teams for the analysis of case studies and challenges. Mobility and internship opportunities are foreseen in the framework of agreements with the other universities involved in the *Technologies for Transitions* project and with companies supporting the project.
The PM is aimed at a variety of figures: students of Master's Degree Courses related to ecological transition issues who want to give a specific connotation to their studies in line with the Minor

addresses; professionals already in the labour market who want to broaden their spectrum of skills on ecological transition issues in the framework of lifelong learning processes for professional qualification/re-skilling.
The PM aims at training a professional figure with skills related to the design and control of the transformations of matter and energy, capable of qualified intervention in the development of solutions for an industrial economy for the production of goods and the provision of services and for the production, use and storage of energy marked by sustainability criteria, based on the efficient use of resources, the implementation of circular economy protocols, the preservation of biodiversity and the reduction of pollution.
Qualifying areas of training activities are: Green and regenerative chemistry; Control, monitoring, prevention and treatment of waste and pollutant emissions; Sustainable production, storage and distribution of energy; Design and reconversion of systems for the production of goods and the provision of services with a view to sustainability: bio-economy, circular economy, industrial symbiosis; Framing of material and energy transformation processes in the principles of industrial ecology.
Additional transversal skills and competences are acquired with reference to: Digital tools to support the greening of processes and products; Elements of legal/regulatory, economic and managerial culture related to energy, environment, sustainability issues.

Art. 3

Admission Requirements for Access to the PM for Students Enrolled in a Univeristy Degree Course

1. Students enrolled in the CdS listed in the Table in Art. 1, section 2, in partial overlap with the studies of the Master's degree in which they are enrolled, may enrol in the Minor.

Art. 4

Requirements for Admission to the PM for Graduate Students or Students from other Universities

1. Access to the Minor is also open to students enrolled at other universities in degree courses in the same degree classes as the degree courses associated with the Minor (as per Article 1, paragraph 2) and students who have already graduated in the degree classes of the degree courses associated with the Minor (as per Article 1, paragraph 2) or equivalent regulations such as ex-Ministerial Decree 509/1999, or who hold degrees acquired abroad and recognised as equivalent for admission purposes by the Coordination Committee.
2. Admission of students who have already graduated or are enrolled at other universities is arranged subject to verification of the compatibility of their previous academic career with the PM's educational objectives.

Art. 5

Mode of Access to the Minor and Personal Preparation Pathway

1. In addition to what is specified in Articles 3 and 4, access to the Minor also requires compliance with specific criteria aimed at assessing the adequacy of the student's personal preparation.
2. For students enrolled in the CdS listed in the Table in Art. 1, paragraph 2, and for students enrolled at other universities in CdS of the same degree classes as the CdS associated with the Minor, the verification of the student's fulfilment of the requirements related to the personal preparation will be carried out by the Committee.

3. For students entering the Minor as undergraduates, the Committee verifies that they meet the requirements for entry to the PM on the basis of their grade and/or curriculum vitae and assesses their admission.

Art. 6
Educational Activities and University Credits

1. The training activities envisaged by the PM correspond to 30 CFU. These activities may be recognised within the career of students enrolled in a degree course at the University; in any case, at least 10 CFUs must be reserved for extracurricular activities in addition to the CFUs of the statutory plan for obtaining the degree (pursuant to Art. 18, c. 1 of the RDA).
2. Students enrolled in an LM among those listed in the Table in Art. 1, paragraph 2, when submitting the application for enrolment in the Minor, shall at the same time submit a study plan for the degree course in which they are enrolled that is consistent with the Minor, also for the purpose of verifying the criterion regarding extra-curricular credits. The study plan must be approved by the competent CCD before the student's admission to the Minor and is considered active upon admission to the Minor.

   The study plan must comply with the following conditions:
   - up to 20 CFU are acquired as curricular credits as part of the minimum 120 CFU for the Master's degree;
   - at least 10 CFU are acquired as extra-curricular credits, in addition to the minimum 120 CFU for a Master's degree;
   - at least two-thirds of the CFUs are acquired in fields other than the characterising fields for the Master's degree of origin.
3. The hours of assisted teaching for each CFU are determined in relation to the type of training activity pursuant to Art. 6, c. 5 of the RDA.
4. The activities are subdivided into ~~4~~ teaching and training activities for the promotion of transversal skills, organised in three groups: Alignment courses listed in Table A providing basic knowledge of Green Technologies; Application courses listed in Table B presenting transversal training activities in the technical-scientific area borrowed from the disciplinary training offered by the various CdS; courses listed in Table C focusing on training activities for the promotion of digital skills; training activities for the promotion of transversal skills such as seminars, Soft Skills, Internships at qualified public or private institutions.

Table A			
Degree Program	Selectable traininig activities	Scientific Sector	CFU
MSc in Chemical Engineering - LM-22	Industrial ecology and green engineering	ING-IND/25	6
MSc in Electrical Engineering - LM-28	Electrical technologies for the ecological transition	ING-IND/31	6
Mechanical Engineering for Energy and Environment - LM-33	Thermo-mechanical technologies for the energy transition	ING-IND/08 (o 09) - ING-IND/10	6
Environmental and Territorial Engineering - LM-35	Circular bioeconomy for the ecological transition	ICAR/03	6
MSc in Materials Engineering - LM-53	Sustainable materials	ING-IND/22	6

Table B				
Class	Degree Program	Selectable traininig activities	Scientific Sector	CFU
LM-22	Chemical Engineering	Environmental chemical engineering	ING-IND/25	6
LM-22	Chemical Engineering	Thermo-chemical conversion of biomass and waste	ING-IND/26	6
LM-22	Chemical Engineering	Sustainable technologies for pollution control	ING-IND/25	6
LM-22	Chemical Engineering	Environmental Health Engineering	ICAR/03	6
LM-22	Chemical Engineering	Industrial chemistry from renewable feedstocks	ING-IND/27	9
LM-22	Chemical Engineering	Sustainable process design	ING-IND/25	9
LM-22	Chemical Engineering	Regenerative chemistry	CHIM/07	6
LM-28	Electrical Engineering	Electric and hybrid vehicles	ING-IND/32	6
LM-35	Environmental and Territorial Engineering	Energy management for transportation	ING-IND/32	9
LM-33	Ingegneria Meccanica per l'Energia e l'Ambiente	Electric Power Plants Based on Traditional and Renewable Sources	ING-IND/33	6
LM-28	Electrical Engineering	Innovative energy systems	ING-IND/08	6
LM-33	Mechanical Engineering for Energy and Environment	Fundamentals of energy efficiency and renewable energy technologies	ING-IND/10	9
LM-33	Mechanical Engineering for Energy and Environment	Advanced energy technologies	ING-IND/10	6
LM-33	Mechanical Engineering for Energy and Environment	Laboratory of thermodynamic systems optimization	ING-IND/10	6
LM-33	Mechanical Engineering for Energy and Environment	Hybrid propulsion systems	ING-IND/08	6
LM-33	Mechanical Engineering for Energy and Environment	Measurements and environmental impact of machinery	ING-IND/09	9
LM-35	Environmental and Territorial Engineering	Smart and electric mobility	ICAR/05	9
LM-35	Environmental and Territorial Engineering	Hydroelectric plants	ICAR/02	9
LM-35	Environmental and Territorial Engineering	Smart, resilient and sustainable city	ICAR/20	9
LM-35	Environmental and Territorial Engineering	Waste to Energy and Circular Economy	ICAR/03	9
LM-35	Environmental and Territorial Engineering	Hydraulics for the Efficiency of Water Systems	ICAR/01	9
LM-53	Materials Engineering	Materials and Technologies for Photovoltaic	ING-IND/22	6
LM-53	Materials Engineering	Nanophasic Material Engineering for Energy and Sensors	ING-IND/22	6

Table C		
Selectable traininig activities	SSD	CFU
Network security	ING-INF/05	6
Machine learning and big data	ING-INF/05	9
Technologies for information systems	ING-INF/05	9

5. The PM students must present and discuss an interdisciplinary Master's thesis on a topic consistent with their chosen profile
6. The CFUs corresponding to each formation activity are accumulated by the student after positive profit verification (examination, suitability) indicated in the Schedule of to the formation activity.
7. Students already in possession of an LM degree (or equivalent) or students enrolled at other universities are required to submit a study plan upon enrolment. The Committee verifies the consistency of the activities chosen by the student with his or her academic career, in order to avoid repeating training activities already undertaken and to check for any propedeuticity. In the case of students enrolled in degree courses at other universities, this check is repeated after the relevant degree has been awarded. The student must accept the study plan approved

by the Committee. If the approved study plan is not adhered to, the student will not be able to obtain the PM completion certificate.

8. For the purposes of the Minor career, students (whether enrolled in a degree course or already graduated) may request the recognition of examinations envisaged in the Minor pathway (or examinations equivalent to them) already taken, subject to the constraint that at least 10 CFUs of the Minor pathway must relate to extra-curricular activities in addition to those that concur or have concurred in the awarding of the degree. Under no circumstances may examinations already passed by students in their previous career be taken again for the purposes of completing the Minor.

Art. 7
Mode of Delivery of Teaching Activities

1. The PM's teaching activities are carried out in the manner laid down by the teaching units to which they belong.
2. Detailed information on how each course is conducted can be found on the Course Sheets on the UniNA lecturers' website.

Art. 8
Period of Running and Conclusion of the Minor Pathway

1. The Minor is achieved on completion of all the activities envisaged in the course and, for students entering the Minor as enrolled in a CoS, not before the achievement of the relevant degree. For students enrolled in a CoS, the Minor is completed when the final degree is awarded, or subsequently within a time frame of normally no more than 1 year. For students who have already graduated, the Minor must be completed within an interval of normally no more than 2 years from admission.
2. At the conclusion of the PM the University issues a specific certification (pursuant to Art. 18, c. 1, of the RDA) also by means of an Open Badge. In the case of students enrolled in the CCdSS listed in the Table in Art. 1, paragraph 2, the Open Badge will highlight the extracurricular credentials acquired.
3. The certification attests that the student has successfully attended the activities envisaged by these Green Technology Developer PM Regulations. It is accompanied by a grade corresponding to the average of the grades obtained in all the training activities envisaged by the PM.
4. For the purposes of PM certification, the competent CCD in relation to the student's Degree Class, having consulted the Committee, certifies the overall skills acquired.

Art. 9
Propredeuticity and Previous Knowledge

1. The list of propaedeuticities may be deduced from the teaching modules in the regulations of the relevant degree programmes.
2. Any prior knowledge deemed necessary for access to the activities envisaged by the PM is indicated in the individual Teaching Schedule published on the UniNA lecturers' website.

Art. 10
Minor Course Schedule

1. The PM's teaching calendar is made available on the website of each PM's proposing department and school, prior to the start of the activities.

Art. 11
Fees and contributions for access to the Minor

1. Students enrolled in one of the University's degree programmes and admitted to the PM have access to the programme free of charge, or, if envisaged by the Board of Directors (BoD), by paying to the University a contribution set annually by the BoD. All other students admitted to the PM pay the University a contribution set by the BoD.
2. Pursuant to Article 18.2 of the RDA, admission to the PM gives rise to a career distinct from that of the course of study to which they are enrolled.

Art. 12
Publicity and entry into force

1. The PM regulations are published on the websites of the LDCs involved well in advance of the start of the training activities.