DIDACTIC REGULATIONS OF THE DEGREE PROGRAM MATHEMATICAL ENGINEERING

CLASS LM-44

School: SCUOLA POLITECNICA E DELLE SCIENZE DI BASE

Department: DIPARTIMENTO DI MATEMATICA E APPLICAZIONI R. CACCIOPPOLI

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

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Art. 1
Object

1. These Didactic Regulations govern the organisational aspects of the CdS in Mathematical Engineering (class LM-44). The CdS in Mathematical Engineering is hinged in Scuola Politecnica e delle Scienze di Base, Department of Matematica e Applicazioni R. Caccioppoli.

Source: SUA-CdS
Framework: General CdS Information

University	Università di Napoli Federico II
Name of the Course in Italian	Ingegneria Matematica
Name of the Course in English	Mathematical Engineering
Class	LM-44 Mathematical-Physics modelling for Engineering
Teaching language	English
Web site of the Course	http://www.mathematical-engineering.unina.it/index.php/en/
Tuition fees	http://www.unina.it/didattica/sportello-studenti/
Teaching method	b. Course of Studies in mixed teaching mode

2. The CdS is governed by the Didactic Coordination Commission (CCD), pursuant to Art. 4 of the RDA.

Source: SUA-CdS
Framework: Contact Person and Structure
Collegial Management Body of the CdS

President (or Referent or Coordinator) of the CdS	MALLOZZI Lina
Managerial institutions of the CdS	Commissione di Coordinamento Didattico, Laurea in Mathematical Engineering
Didactical structure of reference	Matematica e Applicazioni "Renato Caccioppoli"

Teachers of reference

N.	COGNOME	NOME	SETTORE	QUALIFICA	PESO	TIPO SSD
1.	FIORE	Daniele		RD	1	

2.	POLIZZI	Francesco	PO	1
3.	MELE	Valeria	RD	1
4.	FUSCO	Nicola	PO	1
5.	SIETTOS	Konstantinos	PA	1
6.	MATTEI	Maria Rosaria	PA	1
7.	MALLOZZI	Lina	PO	1

Student representative	Rappresentanti degli studenti non indicati
Managerial Group AQ	MARIO DI BERNARDO NICOLA FUSCO RAFFAELE GROTTOLA ANNA MERCALDO
Tutor	Claudio SERPICO Paola FESTA Francesco POLIZZI

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.
4. The CdS in Mathematical Engineering has a training pathway leading to the award of a Double Degree in Mathematical Engineering and in Mathematical Analysis and Modelling.
   The criteria for access to the dual Degree Program, the period of teaching activities abroad and the Table of Correspondence of Training Activities are annexed to these Didactic Regulations.

Art. 2
Training objectives

Source: SUA

Framework: A4.a – RAD

Current engineering practice involves an increasing and often intensive use of advanced mathematical-numerical models, both of a deterministic and stochastic nature. These models are subject to continuous evolution and involve, in many cases, multidisciplinary knowledge, transversal to basic sciences (mathematics, physics, computer science) and engineering. The specific objective of the master's degree Course in Mathematical Engineering is the training of a professional figure who knows how to use the technological knowledge of engineering and the methodologies of applied mathematics to describe and solve complex problems with autonomy and accuracy, researching and estimating a satisfactory adherence to reality, thus optimizing the working times for the user company and, ultimately the costs. For the purposes indicated, the master's degree course in Mathematical Engineering is characterized by a strong integration between mathematics and the disciplines of engineering. The first phase of the training course includes activities that can be considered “basic" in both areas and aim to consolidate the knowledge acquired by the student in the three-year degree courses previously obtained.

In the field of mathematics, the master's degree course in Mathematical Engineering has the following objective:

- provide a solid mathematical training through first the tools of real and functional analysis, on which the study of mathematical models that allow to effectively represent the phenomena of reality is based. These tools will be acquired thanks to didactic activities related to the SSD MATH-03/A;
- deepen the knowledge of mathematical physics and numerical analysis, aimed at proving the qualitative and quantitative study of mathematical models. This knowledge is acquired in the courses of the SSDs MATH-04/A and MATH-05/A.

In the engineering field, the course intends:

- integrate knowledge by providing fundamental teachings in which the themes of behavior and chemical and physical transformations of materials are deepened (didactic activities referable to the SSD IMAT-01/A), electrodynamics and electromagnetism (SSD IIET-01/A), of computational fluid dynamics, with more general applications to continuum mechanics (SSD SSD IIND-01/F), of the dynamics of non-linear systems of engineering interest and their interaction with control systems (SSD IINF-04/A). These issues are addressed with a strong orientation towards the development of models and their application for solving engineering problems.

In the context of these disciplines, which also represent a cultural tradition of excellence that has developed in the University Federico II over the span of over thirty years, the master's degree course in Mathematical Engineering develops curricula of studies that most characterize its preparation with respect to specific applicative sectors. The curricula provide for integrations in mathematics or engineering with specific reference to the areas of industrial, civil or information engineering. The initial activity, mainly in the first year of the first semester, will be delivered electronically by providing courses consisting of a percentage of credits offered by online courses and the rest as a tutoring activity both for teaching support to the course and for complementary topics.

Art. 3
Professional profile and work opportunities

Source: SUA

Framework: A2.a - RAD

Graduates in Mathematical Engineering are professionals capable of performing tasks that require deep knowledge of techniques for the correct formulation of mathematical models and their resolution, especially using numerical analysis tools. He is characterized by a strong ability to tackle advanced engineering problems by identifying and using suitable theoretical and computational tools. Furthermore, he is able to develop and apply appropriate mathematical methods in solving problems, such as advanced finite difference, finite volumes, or finite element techniques, to solve problems governed by partial differential equations, numerical simulation of complex systems or phenomenologies, the statistical study of physical phenomena, variational methods, and to integrate knowledge from different fields. The wide cultural latitude of the Mathematical Engineer puts him in a position to perform a function of connecting technicians with specialized training and experts from other disciplines.

Function in a work context:

The broad-spectrum competence on the main engineering sectors (industrial, civil, information) makes the mathematical engineer a professional figure of potential interest for a wide range of production and research sectors. The problem solver mentality characterizes him with respect to a purely mathematical training, and allows him to face modeling problems typical of technologically advanced contexts, which often require, through the use of advanced mathematical modeling, " time-to-market " shorter than those obtainable through the traditional use of physical modeling and scale-up. The cultural profile of the Mathematical Engineer allows him to enter very profitably in diversified work contexts: public and private development and design centers, advanced technological sectors of industry, such as research laboratories in the fields of engineering, mathematics and physics applied, consulting firms, data processing and numerical code development companies for industry. The cultural profile allows him to effectively perform a plurality of functions: development of advanced models for the simulation of systems of engineering interest, realization of the corresponding calculation tools, support for the design and definition of control logics, systems and both artificial and natural processes, analysis of experimental data and elaboration of interpretative models. He can also profitably develop research, both fundamental and industrial enhancing the skills of analysis, formulation of models and related validation, reading and interpretation of experimental data. Furthermore, the intrinsically interdisciplinary training allows him to take on the coordination functions of working groups with profit.

Skills associated with the function:

The master's degree course in Mathematical Engineering aims to develop a professional profile that allows the graduate to face, with the mindset of an engineer, problems related to phenomenologies and complex systems, in which there is a strong degree of interdisciplinarity, using methodologies offered by the various sectors of applied mathematics. The professional profile includes the following specific skills:

- understand and analyze problems posed by different engineering sectors, concerning both artificial and industrial systems, such as products or artifacts built or constructible by man, and natural systems in which human intervention is absent or negligible, analyzing with the appropriate levels

of space-time resolution the behavior of matter and structures as well as the physical and chemical phenomena that intervene in the transformation processes;
- choose or develop the most suitable physical-mathematical model to analyze the specific problem, also taking into account the development and implementation times and compatibility with the necessary accuracy levels and tolerable complexity;
- model the system of interest in a discrete and/or continuous form with the support of suitable mathematical tools;
- critically analyze from a qualitative and quantitative point of view the output generated by the model and the correspondence with the phenomenon to be analyzed, also through the application of methodologies for evaluating the predictive nature of the model and quantifying uncertainty;
- numerically simulate natural phenomena, industrial processes and the behavior of materials and structures;
- analyze statistical data, synthesize them, adapt them to stochastic models of interest in applications, use them for forecasting purposes in reliability and decision-making analyzes;
- carry out in-depth design studies, based on the use of advanced mathematical procedures.

Job opportunities:
The employment findings relating to the degree courses in Mathematical Engineering already activated at the Politecnico di Milano (starting from the 2001-02 academic year) and at the Turin Polytechnic (starting from the 2004-05 a.y.) highlight that graduates find employment within one year of graduation in various work sectors. Due to the curricular characteristics required, it is believed that master's degree graduates in Mathematical Engineering of the University of Naples Federico II can find easy positions in different work contexts: consulting firms and companies operating in the manufacturing, process, industrial production, electronics, telecommunications, information technology, but also services (banks, insurance companies, financial companies) with specific reference to the development of models and methodologies for the analysis of production systems. Added to these is the possible inclusion in both public and private research structures.
At the local level, also on the basis of a joint analysis carried out as part of a protocol agreement with the Unione degli Industriali della Provincia di Napoli, the following sectors are identified that can best enhance the skills of the graduate in Mathematical Engineering:
Metalworking Industry (in particular Aerospace, Precision Mechanics, Metallurgy, Rolling) Shipbuilding
I.C.T.
Chemical and Materials Industry
Electronic Components Industry
I Plants, Facility Management and Global Service (in particular with regard to renewable energy sources and energy efficiency)
Logistics, Intermodality and Transport (in particular with regard to ICT systems and applications)
Utilities, Energy and Environment
Packaging.
To the industrial sectors must then be added that of research. At the regional level, it is believed that the figure of the mathematical engineer can find concrete employment opportunities at:
University Departments present in Campania;
Institutes of the CNR;
ENEA;
Research Centers of Campania (for example CIRA);
the six Technological Districts promoted by the Campania Region;
the Research and Development sector of some medium-sized companies operating in Campania.

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

Source: SUA

Framework: A3.a – RAD

Access to the master's degree course in Mathematical Engineering will be allowed to students holding a Degree in the Classes L-7 Civil and Environmental Engineering, L-8 Information Engineering, L-9 Industrial Engineering, L- 23 Building Sciences and Techniques, L-35 Mathematical Sciences.
In particular, the student must have acquired a minimum of 24 CFU in mathematics SSD, of which 6 in MATH-02/B and 18 in MATH-03/A, a minimum of 12 CFU in physics SSD PHYS-01/A and a minimum of 6CFU in INFO-01/A or IINF-05/A.
Knowledge of the English language corresponding to at least B2 level will also be required. The didactical regulations of the course of study define the curricular specifics required for admission and the procedures for verifying the student's personal preparation.

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].

Source: SUA

Framework: A3.b

Admission to the master's degree course in Mathematical Engineering will be arranged by the Commissione di Coordinamento Didattico after checking:
a) the requirement of knowledge of the English language, corresponding to a level of knowledge not lower than level B2, possibly attested by suitable certification;
b) the adequacy of the student's personal preparation, for the purposes of admission to the Master's Degree Course, according to the provisions of the art. 6 comma 2 of D.M. 16 marzo 2007, with procedures common to the Master's Degree Courses in Engineering governed by the device of the Scuola Politecnica e delle Scienze di Base of the University of Naples Federico II.

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.

[1] Artt. 7, 13, 14 of the University Didactic Regulations.
[2] National programmed access is regulated by L. 264/1999 and subsequent amendments and supplements.
[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".

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]:
- Frontal lesson: from 5 to 10 hours for CFU;
- Seminar: from 6 to 10 hours for CFU;
- Practical laboratory activities: from 8 to 12 hours for CFU;
- Internship: 25 hours for CFU4.

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 teaching activity is carried out in a mixed mode. [include what is indicated in the SUA-CdS Framework 'General Information on the Degree Program', Course delivery methods[6]]
The CCD decides how many and which courses provide for educational activities offered online in the educational offer of each academic year. The initial activity, mainly in the first year of the first semester, will be delivered electronically by providing courses consisting of a percentage of credits offered by online courses and the rest as a tutoring activity both for teaching support to the course and for complementary topics.
Some courses may also take place in seminar form and/or include classroom exercises, language and computer labs. Detailed information on the methods of carrying out each course will be found in the course details.

Art. 8
Testing of training activities[7]

1. The CCD, within the prescribed regulatory limits[8], establishes the number of examinations and other means of assessment that determine the acquisition of credits. Examinations are individual

[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. [please indicate below in the note any different regulatory provisions, e.g., "LM-13: 1 CFU = 30 hours, Note MUR, Director Cuomo, Prot. 570/2011; LM-51, L-24: 1 CFU = 20 hours professional training activity + 5 hours of further supervised training activity, D.M. 654/2022 (Art. 2, practical-assessment Internship)"]

[6] Please note that, according to Ministerial Decree 289 of 25 March 2021 (general guidelines for the three-year planning of universities 2021-2023), in Annex 4, letter A, the types of programs are as follows:

a) Conventional Degree Programs. Degree Programs delivered entirely in person, or which provide - for activities other than practical and laboratory activities - a limited teaching activity delivered electronically, to an extent not exceeding one tenth of the total.

b) Degree Programs with mixed modality. Degree Programs that provide - for activities other than practical and laboratory activities - a significant proportion of the training activities delivered electronically, but no more than two-thirds.

c) Degree Programs mainly delivered by distance teaching. Degree Programs delivered predominantly by telematic means, to an extent exceeding two-thirds (but not all) of the training activities.

d) Degree Programs delivered entirely by distance. In these Degree Programs all the training activities are delivered electronically; the presence of the examinations of profit and discussion of the final examinations remains unaffected.

[7] Article 22 of the University Didactic Regulations.

[8] 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

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's website.[9]
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 [10].

Art. 9
Degree Program structure and Study Plan

1. The legal duration of the Degree Program is 2 years. It is also possible to enroll on the basis of a contract according to the rules set by the University (Art. 24 Regolamento Didattico di Ateneo).

The student must acquire 120 CFU[11], attributable to the following Types of Training Activities (TAF):

B) characterising, 75
C) related or complementary, 12
D) at the student's choice[12], 12
E) for the final exam, 18
F) further training activities, 3.

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. 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".

[9] 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."

[10] 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."

[11] 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.

[12] 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).

2. The degree is awarded after having acquired 120 CFU by passing examinations, not exceeding 12 [insert the number of examinations: "20" (Bachelor's Degree), "12, including the final"[13] (Master's Degree), '30, including the final exam' (five-year single-cycle Degree), '36, including the final exam' (six-year single-cycle Degree)], 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. Examinations or assessments relating to activities independently chosen by the student may be taken into account in the overall calculation corresponding to one unit[14]. 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[15] 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 that 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 CCD.

Art. 10
Attendance requirements[16]

1. In general, attendance of lectures is a) 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.

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[13] Art. 14, par. 7 of the University Didactic Regulations ('the final exam for the Master's Degree is included in the calculation of the maximum number of exams').

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

[15] 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".

[16] 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 at the end of Annex 1 and in the teaching/activity course sheet (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's 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[17]

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[18]; 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.

[17] Art. 19 of the University Didactic Regulations.
[18] Art. 19 and Art. 27, c.6 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 [19].

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[20].
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.) 931/2004, 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[21], is governed by the "University Regulations for enrolment in individual teaching courses activated as part of the Degree Program"[22].

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

Article 16
Features and modalities for the final examination

Source: SUA

Framework: A5a (RAD) and A5b

The final exam consists in the discussion of a thesis prepared by the student that reports original results referring to advanced topics of engineering interest. The thesis must meet the requirement of appropriately balancing the analysis of the engineering problem and the development of mathematical modeling tools functional to its resolution. The thesis will be prepared by the candidate under the guidance of one or more supervisors, including those outside the master's degree course. The preparation of the thesis can also be carried out in public or private companies, as well as in research centers or university laboratories for a period of time congruent with the credits assigned.

The exam for the final qualification consists in a public discussion of the thesis, also presented in written form, in the presence of an examination commission, according to the procedures governed by the University Didactic Regulations. The discussion aims to ascertain the ability of synthesis and the cultural maturity reached by the student at the end of the study curriculum, within the scope of the competences required in the educational objectives of the course of study. In particular, the student must demonstrate mastery of the topics covered, the ability to operate independently and a good level of communication skills.

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/are not [delete one of the two options] 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[23].
2. The CCD regulates the modalities and characteristics of traineeship and internship with specific regulations.
3. Through ORIENTA UNINA https://www.orientamento.unina.it, the University of Naples Federico II, ensures constant contact with the world of work, to offer concrete opportunities to students and graduates of the University of internships and stages and promote their professional integration. The Course of Study participates in the actions undertaken by the Scuola Politecnica e delle Scienze di Base, such as the events "La Scuola incontra le Aziende" and the "Career Day" and collaborates in populating the jobservice platform of the Scuola Politecnica e delle Scienze di Base, which is an important tool for students to enter the world of work.

Article 18
Disqualification of student status[24]

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.

[23] Traineeships ex letter d can be both internal and external; traineeships ex letter e can only be external.

[24] Art. 24, c. 5 of the University Didactic Regulations.

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[25].
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 organized by ORIENTA UNINA (Orientation and Placement www.orientamento.unina.it) and by Centro SInAPSI di Ateneo (for all students who feel excluded from university life due to disabilities, Specific Learning Disorders www.sinapsi.unina.it), in collaboration with the individual Didactical Structures, as established by the RDA in article in 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)[26] 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.
3. 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.

Article 21

[25] R.D No. 2482//2020.

[26] 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.

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) and Annex 2 (Teaching/Activity course sheet) are integral parts of this Didactic Regulations.
3. Annex 3 (Criteria for access to the Double Degree Program and the period of teaching activities abroad) and Annex 4 (Table of correspondence of teaching activities) are also integral parts of this Didactic Regulations.

ANNEX 1.2

DEGREE PROGRAM DIDACTIC REGULATIONS

MATHEMATICAL ENGINEERING

CLASS LM- 44

School: SCUOLA POLITECNICA E DELLE SCIENZE DI BASE

Department: DIPARTIMENTO DI MATEMATICA E APPLICAZIONI R. CACCIOPPOLI

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

Curriculum A

I Year -curriculum A

Title Course	SSD	Module	Credits	Hours	Type Activities	TAF	Disciplinary area	Mandatory / optional
Real and Functional Analysis	MATH-03/A	Single – 1 sem	9	72	Frontal lesson/MOOC	B	Mathematics, physics, computer science disciplines	Mandatory
Mathematical Physics Models	MATH-04/A	Single – 1 sem	9	72	Frontal lesson/MOOC	B	Mathematics, physics, computer science disciplines	Mandatory
Numerical Methods	MATH-05/A	Single – 2 sem	9	72	Frontal lesson	B	Mathematics, physics, computer science disciplines	Mandatory
Thermodynamics and Transport Phenomena	IMAT-01/A	Single – 2 sem	9	72	Frontal lesson	B	Engineering disciplines	Mandatory
Nonlinear Systems	IINF-04/A	Single – 2 sem	9	72	Frontal lesson	B	Engineering disciplines	Mandatory
Mathematical Methods for Engineering	MATH-03/A	Single – 1 sem	6	48	Frontal lesson/MOOC	B	Mathematics, physics, computer science disciplines	Mandatory (one of your choices) GROUP 1
Calculus of Variations	MATH-03/A	Single – 2 sem	6	48	Frontal lesson/MOOC	B	Mathematics, physics, computer science disciplines	
Discrete Mathematics	MATH-02/A	Single – 2 sem	6	48	Frontal lesson	B	Mathematics, physics, computer science disciplines	
Operational Research	MATH-06/A	Single – 1 sem	6	48	Frontal lesson	B	Mathematics, physics, computer science disciplines	
Differential Geometry	MATH-02/B	Single – 2 sem	6	48	Frontal lesson/MOOC	B	Mathematics, physics, computer science disciplines	
Algorithms and Parallel Computing	INFO-01/A	Single – 2 sem	6	48	Frontal lesson	B	Mathematics, physics, computer science disciplines	
Deep Learning	INFO-01/A	Single – 2 sem	6	48	Frontal lesson	B	Mathematics, physics, computer science disciplines	
Statistical Methods and Signal Theory	STAT-01/B	Module 1: Statistical Methods for Industrial Process Monitoring	6	48	Frontal lesson	C	Economic and statistics/Engineering disciplines	Mandatory (one of your choices) GROUP 3
	IINF-03/A	Module 2: Signal theory	6	48	Frontal lesson	C		
Statistical Methods and Economic Theory	STAT-01/B	Module 1: Statistical Methods for Industrial Process Monitoring	6	48	Frontal lesson	C	Economic and statistics disciplines	
	STAT-04/A	Module 2: Economic theory	6	48	Frontal lesson	C		
Modern and Solid State Physics	PHYS-02/A	Module 1: Modern Physics	6	48	Frontal lesson	C	Mathematics, physics, computer science disciplines	
	PHYS-04/A	Module 2: Solid State Physics	6	48	Frontal lesson	C		
Numerical Modeling of Materials and Solid-State Physics	CHEM-04/A	Module 1: Numerical Modeling of Materials	6	48	Frontal lesson	C	Chemistry/Physics disciplines	
	PHYS-04/A	Module 2: Solid State Physics	6	48	Frontal lesson	C		

II Year – curriculum A

Computational Fluid Dynamics	IIND-01/F	Single – 1 sem	9	72	Frontal lesson	B	Engineering disciplines	Mandatory
Electrodynamics of continuous media	IIET-01/A	Single – 2 sem	9	72	Frontal lesson	B	Engineering disciplines	Mandatory
Optoelectronics	IINF-01/A	Single – 2 sem	6	48	Frontal lesson	B	Engineering disciplines	Mandatory (one of your choices) GROUP 2
Electromagnetic Fields	IINF-02/A	Single – 1 sem	6	48	Frontal lesson	B	Engineering disciplines	
Information Theory	IINF-03/A	Single – 1 sem	6	48	Frontal lesson	B	Engineering disciplines	
Systems Identification and Control	IINF-04/A	Single – 1 sem	6	48	Frontal lesson	B	Engineering disciplines	
Waves	IIND-01/F	Single – 2 sem	6	48	Frontal lesson	B	Engineering disciplines	
Autonomously chosen topics			12			D		
Other			3			F		
Final test			18			E		

Curriculum B

I Year – curriculum B

Title Course	SSD	Module	Credits	Hours	Type Activities	TAF	Disciplinary area	Mandatory / optional
Real and Functional Analysis	MATH-03/A	Single – 1 sem	9	72	Frontal lesson/MOOC	B	Mathematics, physics, computer science disciplines	Mandatory
Mathematical Physics Models	MATH-04/A	Single – 1 sem	9	72	Frontal lesson/MOOC	B	Mathematics, physics, computer science disciplines	Mandatory
Numerical Methods	MATH-05/A	Single – 2 sem	9	72	Frontal lesson	B	Mathematics, physics, computer science disciplines	Mandatory
Thermodynamics and Transport Phenomena	IMAT-01/A	Single – 2 sem	9	72	Frontal lesson	B	Engineering disciplines	Mandatory
Nonlinear Systems	IINF-04/A	Single – 2 sem	9	72	Frontal lesson	B	Engineering disciplines	Mandatory
Mathematics for Cryptography	INFO-01/A	Single – 1 sem	6	48	Frontal lesson	B	Mathematics, physics, computer science disciplines	Mandatory (one of your choices) GROUP 1
Stochastic Processes	MATH-03/B	Single – 1 sem	6	48	Frontal lesson/MOOC	B	Mathematics, physics, computer science disciplines	
Partial Differential Equations	MATH-03/A	Single – 1 sem	6	48	Frontal lesson	B	Mathematics, physics, computer science disciplines	
Advanced Applied Engineering Mathematics	MATH-04/A	Single – 2 sem	6	48	Frontal lesson	B	Mathematics, physics, computer science disciplines	
Algebraic Structures and Advanced Linear Algebra	MATH-02/A	Single – 2 sem	6	48	Frontal lesson	B	Mathematics, physics, computer science disciplines	
Computational Complexity	INFO-01/A	Single – 2 sem	6	48	Frontal lesson	B	Mathematics, physics, computer science disciplines	
Geometric Structures and Topology	MATH-02/B	Single – 2 sem	6	48	Frontal lesson	B	Mathematics, physics, computer science disciplines	
Statistical Methods and Chemical Process	STAT-01/B	Module 1: Statistical Methods for Industrial Process Monitoring	6	48	Frontal lesson	C	Economic and statistics/Chemistry disciplines	Mandatory (one of your choices) GROUP 3
	ICHI-01/C	Module 2: Chemical Process Analysis and Simulation	6	48	Frontal lesson	C		
Statistical Methods and Economic Theory	STAT-01/B	Module 1: Statistical Methods for Industrial Process Monitoring	6	48	Frontal lesson	C	Economic and statistics disciplines	
	STAT-04/A	Module 2: Economic theory	6	48	Frontal lesson	C		
Modern and Solid State Physics	PHYS-02/A	Module 1: Modern Physics	6	48	Frontal lesson	C	Mathematics, physics, computer science disciplines	
	PHYS-04/A	Module 2: Solid State Physics	6	48	Frontal lesson	C		
Numerical Modeling of Materials and Solid-State Physics	CHEM-04/A	Module 1: Numerical Modeling of Materials	6	48	Frontal lesson	C	Chemistry/Physics disciplines	
	PHYS-04/A	Module 2: Solid State Physics	6	48	Frontal lesson	C		

II Year – curriculum B

Computational Fluid Dynamics	IIND-01/F	Single - 1 sem	9	72	Frontal lesson	B	Engineering disciplines	Mandatory
Electrodynamics of continuous media	IIET-01/A	Single – 2 sem	9	72	Frontal lesson	B	Engineering disciplines	Mandatory
Mechanical Vibrations	IIND-02/A	Single – 2 sem	6	48	Frontal lesson/MOOC	B	Engineering disciplines	Mandatory (one of your choices) **GROUP 2**
Electromagnetic Fields	IINF-02/A	Single – 2 sem	6	48	Frontal lesson	B	Engineering disciplines	
Heat Transfer	IIND-07/A	Single – 2 sem	6	48	Frontal lesson	B	Engineering disciplines	
Analysis and Control of Complex Systems	IINF-04/A	Single – 1 sem	6	48	Frontal lesson	B	Engineering disciplines	
Nonlinear Dynamics and Control	IINF-04/A	Single – 1 sem	9	48	Frontal lesson	B	Engineering disciplines	
Environment Fluid Mechanics and Hydraulics	CEAR-01/A	Single – 1 sem	6	48	Frontal lesson	B	Engineering disciplines	
Theory of Elasticity	CEAR-06/A	Single – 1 sem	6	48	Frontal lesson	B	Engineering disciplines	
Autonomously chosen topics			12			D		
Other			3			F		
Final test			18			E		

ANNEX 2.1

DEGREE PROGRAM DIDACTIC REGULATIONS

MATHEMATICAL ENGINEERING

CLASS LM-44

School: SCUOLA POLITECNICA E DELLE SCIENZE DI BASE

Department: DIPARTIMENTO DI MATEMATICA E APPLICAZIONI R. CACCIOPPOLI

Didactic Regulations in force since the academic year 2025-2026

<table>
<tr><td colspan="2">Course:
ADVANCED APPLIED ENGINEERING MATHEMATICS</td><td>Teaching Language:
English</td></tr>
<tr><td colspan="2">SSD (Subject Areas):
MATH-04/A</td><td>CREDITS:
6</td></tr>
<tr><td>Course year: I</td><td colspan="2">Type of Educational Activity: B</td></tr>
<tr><td colspan="3">Teaching Methods:
In person</td></tr>
<tr><td colspan="3">Contents extracted from the SSD declaratory consistent with the training objectives of the course:
Skills related to the development of rigorous mathematical models, both deterministic and stochastic, for the description of phenomena in the biomathematical, social, economic and industrial fields as well as the physical-mathematical aspects of artificial intelligence and data analysis. From the methodological point of view, the sector makes use of rigorous analytical, probabilistic, algebraic, geometric and computational mathematical techniques.</td></tr>
<tr><td colspan="3">Objectives:
The aim of the course is to introduce the fundamental principles of mathematical modelling 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 numerical discussion of each type of equation will be always preceded by the introduction/derivation of the models. Moreover, the role of initial and boundary conditions will be pointed out with reference to physical situations. The numerical investigation will concern the development of special applications on MATLAB platform.</td></tr>
<tr><td colspan="3">Propaedeuticities:
Is a propaedeuticity for:</td></tr>
<tr><td colspan="3">Types of examinations and other tests:
Oral examination, project discussion.</td></tr>
</table>

Course: ALGEBRAIC STRUCTURES AND ADVANCED LINEAR ALGEBRA	**Teaching Language:** English
SSD (Subject Areas): MATH-02/A	**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: Algebra develops methods and theories to deal with algorithms, formulas and in general abstract and symbolic concepts such as "algebraic structures" (such as for example groups, rings, modules) and their representations. It is constantly evolving both in methods and in results and applications (including cryptography, computer algebra, and those in theoretical physics and science in general).	
Objectives: To provide students with a good understanding of the concepts and methods of advanced linear algebra aimed at solving engineering problems.	
Propaedeuticities: **Is a propaedeuticity for:**	
Types of examinations and other tests: Oral examination.	

Course: ALGORITHMS AND PARALLEL COMPUTING	**Teaching Language:** English
SSD (Subject Areas): INFO-01/A	**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: Computational systems and processes and the automatic processing of information; methodological, technological aspects. Scientific and training activities relating to the design, implementation, management and use of information systems. The skills concern the conceptual foundations and applications of information technology, used in the various disciplines for solving problems using the computational approach. The field includes algorithms and data structures (design, experimentation and analysis; non-classical algorithms).	
Objectives: To deal with the basic ideas, methodologies, tools and software to design and develop algorithms in High Performance Parallel/Distributed Computing Environments. The Lab practice plays a key role in this course.	
Propaedeuticities: **Is a propaedeuticity for:**	
Types of examinations and other tests: Lab tests during the course; final written/oral test.	

Course: ANALYSIS AND CONTROL OF COMPLEX SYSTEMS	**Teaching Language:** English
SSD (Subject Areas): IINF-04/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 sector studies methods and technologies for information processing aimed at modeling, automatic control in real time, supervision, planning and management of plants, processes and dynamic systems in general. The approach offered allows to abstract from the particular application domain dynamic structural properties that can be represented through appropriate classes of mathematical models. This makes it possible to unify the methods for analyzing complex dynamic systems - artificial and natural - and designing control and management systems in order to give them forms of intelligence, learning, robustness, reliability and autonomy that ensure, even without direct human intervention, optimized programmed behaviors, adaptability, self-diagnosis of faults and restoration of normal operating conditions.

Objectives:
This course aims at introducing students to the key theoretical and numerical tools for the analysis and control of complex systems and networks of interconnected dynamical systems. The theoretical concepts will be illustrated via a set of representative examples from Engineering and Applied Science.

Propaedeuticities:
Is a propaedeuticity for:

Types of examinations and other tests:
Oral examination and project work.

Course: CALCULUS OF VARIATIONS	**Teaching Language:** English
SSD (Subject Areas): MATH-03/A	**CREDITS:** 6
Course year: I	**Type of Educational Activity: B**

Teaching Methods:
3 CFU in presence, 3 CFU MOOC (Massive Open Online Courses)

Contents extracted from the SSD declaratory consistent with the training objectives of the course:
Elaboration of rigorous and innovative methodologies for the analysis of problems that emerge both within mathematics and in applications to physical, natural, social and life sciences, computer science and to technological innovation, within the approach of calculus of variations.
Development of new analytical methods to place the study and validation of mathematical models for the life, economic and social sciences, engineering, IT and artificial intelligence in a rigorous framework, also in the light of numerical simulations and data analysis.

Objectives:
The students will acquire the fundamental notions, tools and techniques of the modern theory of Calculus of Variations, with particular focus on its applications within applied and numerical sciences.

Propaedeuticities:
Is a propaedeuticity for:

Types of examinations and other tests:
Oral examination.

Course: COMPUTATIONAL COMPLEXITY	**Teaching Language:** English
SSD (Subject Areas): INFO-01/A	**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: Computer science is the science that deals with computational systems and processes and the automatic processing of information and studies its foundational, methodological, technological, social and educational aspects. The sector is interested in scientific and training activities relating to the design, implementation, management and use of information systems. The skills concern the conceptual foundations and applications of information technology, used in the various disciplines for solving problems using the computational approach. The field includes algorithms and data structures (design, experimentation and analysis; non-classical algorithms, including quantum ones; combinatorial and probabilistic structures; information theory; data compression and integrity).	
Objectives: This course is the ideal complement of a course in algorithmics. It provides an in-depth knowledge of the inherent complexity of problems and the resources needed to solve them with algorithms. As such, it provides criteria for assessing the optimality of algorithms. The course expands on the relationships between memory and time requirements, and on the role of nondeterminism in assessing the difficulty of problems whose complexity is not exactly known. This part has important links with cryptography, operational research, and combinatorial optimization.	
Propaedeuticities: **Is a propaedeuticity for:**	
Types of examinations and other tests: Written and oral examination.	

Course: COMPUTATIONAL FLUID DYNAMICS	**Teaching Language:** English
SSD (Subject Areas): IIND-01/F	**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 course deals with the study of the motion of fluids with particular reference to applications in the engineering field and of the study of Newtonian fluids in conditions of incompressible motion. In particular, the course teaches the fundamentals of fluid dynamics, the main phenomenologies and technological applications in aerodynamics and hydrodynamics and the related numerical methods.	
Objectives:	

The aim of the course is to provide students with the theoretical foundations of numerical discretization of fluid flow equations, as well as to permit them to understand and apply the basic techniques of modern Computational Fluid Dynamics.
Propaedeuticities: **Is a propaedeuticity for:**
Types of examinations and other tests: Written text on a case study and oral examination.

Course: DEEP LEARNING	**Teaching Language:** English	
SSD (Subject Areas): INFO-01/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 "Deep Learning" course aligns with various domains outlined in the declaratory of the Scientific Disciplinary Sector (SSD) INFO-01. The course delves into advanced aspects of artificial intelligence, particularly focusing on deep learning techniques, which are integral to the "machine learning" and "automatic reasoning" components mentioned in the declaratory. Students will engage with complex neural network architectures, such as convolutional and recurrent networks, which fall under the broader categories of "algorithms and data structures" and "management and analysis of data and knowledge." The course also covers the ethical implications of AI, touching upon the societal and professional aspects highlighted in the declaratory's focus on "digital transformation and IT education." Through the practical application of deep learning frameworks, students will develop skills in designing and implementing AI systems, consistent with the declaratory's emphasis on the "design, implementation, management, and use of IT systems."		
Objectives: The "Deep Learning" course aims to equip students with advanced knowledge and skills in the field of deep learning, a critical subdomain of artificial intelligence. Through this course, students will gain a comprehensive understanding of deep learning architectures, including neural networks, convolutional networks, recurrent networks, and generative models. They will explore the mathematical foundations that underpin these models, enabling them to design, implement, and optimize deep learning algorithms for complex, real-world problems. The course also emphasizes the importance of practical applications, offering hands-on experience with contemporary deep learning frameworks and tools. Additionally, students will engage with the ethical considerations surrounding the deployment of AI systems, learning to critically assess the societal impacts, biases, and ethical dilemmas that may arise in the application of deep learning technologies. By the end of the course, students will have developed the expertise necessary to independently tackle complex engineering challenges using deep learning techniques, preparing them for both industry roles and further academic research in this rapidly evolving field.		
Propaedeuticities: **Is a propaedeuticity for:**		
Types of examinations and other tests:		

Discussion of the project work.

Course: DIFFERENTIAL GEOMETRY	**Teaching Language:** English	
SSD (Subject Areas): MATH-02/B		**CREDITS:** **6**
Course year: I	**Type of Educational Activity: B**	
Teaching Methods: 3 CFU in presence, 3 CFU MOOC (Massive Open Online Courses)		
Contents extracted from the SSD declaratory consistent with the training objectives of the course: Study of the properties of differentiable structures.		
Objectives: The aim is to provide students with a good understanding of the concepts and methods of differential geometry.		
Propaedeuticities: **Is a propaedeuticity for:**		
Types of examinations and other tests: Oral examination.		

Course: DISCRETE MATHEMATICS	**Teaching Language:** English	
SSD (Subject Areas): MATH-02/A		**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: Algebra develops methods and theories to deal with algorithms, formulas and in general abstract and symbolic concepts such as "algebraic structures" (such as for example groups, rings, modules, semigroups, Lie algebras and their generalizations) and their representations. It also includes algebraic combinatorics, algebraic number theory, homological algebra and category theory. It is in close symbiosis with other mathematical disciplines with which it forms indissoluble bonds, such as operator algebras, algebraic geometry, algebraic topology. It is constantly evolving both in methods and in results and applications (including cryptography, computer algebra, and those in theoretical physics and science in general). The teaching skills concern, in addition to the topics set out above and the fundamental teachings of the sector, all the teachings relating to basic mathematics contents.		
Objectives: The aim of the course is to introduce students to mathematical ideas and techniques that will be useful in different types of applications. In particular, students will learn the basic algebraic concepts and terminology, so that they will be able how to use and analyse recursive definitions, and to work inside some different types of discrete structures. Moreover, they will learn techniques for constructing mathematical proofs, with the support of various examples.		
Propaedeuticities: **Is a propaedeuticity for:**		
Types of examinations and other tests:		

Oral examination.

Course: ELECTRODYNAMICS OF CONTINUOUS MEDIA	**Teaching Language:** English	
SSD (Subject Areas): IIET-01/A		**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 disciplinary scientific sector studies the theoretical and experimental aspects and the development of the related applications of the two complementary research lines of electromagnetic fields and electrical and electronic circuits in civil, industrial and information engineering. In the first line, 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 analogue and digital, and the related models are studied: linear, non-linear and time-varying, lumped and distributed parameters, signal and power, mono 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, electrothermal energy, electromagnetic compatibility, quality, safety and environmental impact in electrical applications, signal processing circuits, adaptive circuits and neural networks, power electronics and electrical energy conversion. The teaching skills range from the fundamentals of electrical engineering to the research and application topics of the sector.		
Objectives: The aim of the course is to attain a general understanding of Classical Electrodynamics with a special attention to the mathematical aspects of the theory. A central theme in the course is the description, within the continuum approach, of the interactions of electromagnetic fields and material media.		
Propaedeuticities: **Is a propaedeuticity for:**		
Types of examinations and other tests: Oral interview.		

Course: ELECTROMAGNETIC FIELDS	**Teaching Language:** English	
SSD (Subject Areas): IINF-02/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 scientific disciplinary sector is interested in scientific and educational-training activities related to electromagnetic fields. In particular, the knowledge of electromagnetic phenomena, based on the solutions of Maxwell's equations, is combined with the engineering aspects of the development and		

management of electrical, electronic, radio, optical and photonic components, circuits and systems, and of algorithms for data processing.
Objectives: The course provides the Engineering perspective to support comprehension and exploitation of Electromagnetic Fields. Theory, techniques, methods, algorithms and engineering applications are presented.
Propaedeuticities: **Is a propaedeuticity for:**
Types of examinations and other tests: Oral examination.

Course: ENVIRONMENT FLUID DYNAMICS AND HYDRAULICS		**Teaching Language:** English
SSD (Subject Areas): CEAR-01/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 disciplinary scientific sector develops the topics of fluid mechanics and its applications in engineering and studies the laws of fluid motion and the transport processes associated with it, according to a theoretical, computational and experimental approach, through physical models and field measurements. Application domains include: natural water bodies; hydraulic devices.		
Objectives: The course will provide students with an introduction to the problem of the closure of fluid dynamic turbulence. Some models of zero, one and two equations will be illustrated. An application problem will be solved by using a commercial software for the numerical solution of the presented equations. The course will develop a comprehensive view of unsteady free surface flows of water, considered as an incompressible fluid, at a large scale (rivers, lakes) by recovering the fundamental equations in 1 and 2 spatial dimensions. Numerical solutions by finite volume and finite difference methods will be developed for 1D and 2D models.		
Propaedeuticities: **Is a propaedeuticity for:**		
Types of examinations and other tests: Oral examination.		

Course: GEOMETRIC STRUCTURES AND TOPOLOGY		**Teaching Language:** English
SSD (Subject Areas): MATH-02/B		**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 sector includes skills and research areas related to geometry and, in particular, the study of the properties of geometric structures and topological, algebraic, differential and analytics (real and complex), and their classification. More generally, it includes geometry and topology in all their aspects, including algebraic, complex analytic, arithmetic, combinatorial, computational, descriptive, differential, dynamic, and metric. The sector also includes research in the geometric fields listed above inspired by emerging themes or applications. The teaching skills concern, in addition to the topics set out above and the fundamental teachings of the sector, all the teachings relating to basic mathematics contents.

Objectives:
The course aims to provide basic knowledge in General and Algebraic Topology, especially to students with an unsatisfactory background in Geometry.

Propaedeuticities:
Is a propaedeuticity for:

Types of examinations and other tests:
Oral examination.

Course: HEAT TRANSFER	**Teaching Language:** English
SSD (Subject Areas): IIND-07/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 disciplinary scientific sector covers, on a scientific and educational-training level, the fundamental and applicative aspects of thermodynamics, heat transmission, energetics and thermo-fluid dynamics. More specifically, it includes skills relating to the thermodynamic and thermokinetic analysis of energy processes and their environmental impact, the principles of sustainable energy conversion and the use of energy, including from renewable sources, the management of energy and techniques for monitoring and processing energy data and models, energy efficiency, thermoeconomics, energy transition. It also studies thermo-fluid-dynamic phenomena at all scales, even in multiphase systems, in biological and agri-food systems, refrigeration technologies, thermotechnical systems, heat exchange and energy storage systems and components, fire safety, the thermophysical properties of the materials, the thermo-fluid-dynamic measurements and adjustments.

Objectives:
The course introduces basic concepts and principles of heat transfer. It covers analytical, empirical and numerical techniques for the solution of heat transfer problems. The aim of the course is to understand the fundamentals of heat transfer mechanisms and their applications in various heat transfer equipment.

Propaedeuticities:
Is a propaedeuticity for:

Types of examinations and other tests:
Written and oral examination, project discussion.

Course:	**Teaching Language:**

INFORMATION THEORY	English
SSD (Subject Areas): IINF-03/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 disciplinary scientific sector brings together the skills that combine telecommunications methodologies with the design of complex interconnected systems in order to contribute to the development and evolution of information and communication technologies that characterize the "information society". The sector deals with the study and design of systems and services in the following areas: - acquisition, models and coding of real and synthetic multimedia signals (audiovisual, 3D and more); numerical processing and machine learning of signals for information communication, pattern recognition, semantic interpretation of information content; human-machine communication; - transmission of information with radio, optical and acoustic carriers. Modeling of communication systems. Modulation, synchronization and channel estimation. Source and channel coding. Multiple access techniques. Cognitive radio, cooperative systems, relay and multi-hop. Communication and sharing of large amounts of data. Molecular and quantum communications; - protocols and algorithms for the distribution, switching and transport of information on networks and systems, with reference to the entire protocol stack. Design, management and optimization of network and service infrastructures. Programmable and virtualized networks and sensor networks. Network aspects of IoT and cloud-edge; remote sensing technologies and systems for the acquisition of signals and images using sensors, including cognitive ones, for example optical and radar; processing, analysis, extraction and fusion of information for the detection, tracking and recognition of objects and people; terrestrial and satellite localization and navigation systems; - signal intelligence: encryption, marking, biometrics and forensic analysis; physical layer security; monitoring of telecommunications networks and systems; security of interconnection and representation in distributed systems. Typical teaching skills in the sector include: signal theory, theory of random phenomena, information theory, theory of detection and estimation, numerical signal processing, statistical signal processing, information transmission, telecommunications networks and systems.	
Objectives: The field is at the intersection of mathematics, statistics, computer science. The course is highly recommended for students and researchers in fields of communications, data compression, and statistical signal processing. However, it would be invaluable also for students, planning to delve into fields ranging from neuroscience to machine learning. Students will acquire high familiarity with measures of information and uncertainty such as mutual information, entropy, and relative entropy. Students in probability and statistics will gain an appreciation for the interplay between information theory, combinatorics, probability, and statistics.	
Propaedeuticities: **Is a propaedeuticity for:**	
Types of examinations and other tests: Written/oral examination.	

Course: MATHEMATICAL METHODS FOR ENGINEERING	**Teaching Language:** English
SSD (Subject Areas): MATH-03/A	**CREDITS:** **6**
Course year: I	**Type of Educational Activity: B**

Teaching Methods: 3 CFU in presence, 3 CFU MOOC (Massive Open Online Courses)
Contents extracted from the SSD declaratory consistent with the training objectives of the course: Research in the Mathematical Analysis sector aims at the elaboration of rigorous and innovative methodologies for the analysis of problems that emerge both within mathematics and in applications to physical, natural, social and life sciences, computer science and to technological innovation. The sector includes a broad spectrum of skills and research fields among which: real analysis, theories of measure, integration and approximation, complex analysis, harmonic analysis, functional analysis, ordinary differential equations, partial differential equations. The teaching skills concern, in addition to the topics set out above and the fundamental teachings of the sector, all the teachings relating to basic mathematics contents.
Objectives: To provide the fundamental concepts and results, in view of applications, related to the theory of analytic functions, distributions, Fourier series, Fourier and Laplace transforms and their applications.
Propaedeuticities: **Is a propaedeuticity for:**
Types of examinations and other tests: Written and oral examination.

Course: MATHEMATICAL PHYSICS MODELS	**Teaching Language:** English
SSD (Subject Areas): MATH-04/A	**CREDITS:** **9**
Course year: I	**Type of Educational Activity: B**
Teaching Methods: 6 CFU in person, 3 CFU MOOC (Massive Open Online Courses)	
Contents extracted from the SSD declaratory consistent with the training objectives of the course: Skills related to the development of rigorous mathematical models, both deterministic and stochastic, for the description of phenomena in the biomathematical, social, economic and industrial fields as well as the physical-mathematical aspects of artificial intelligence and data analysis. From the methodological point of view, the sector makes use of rigorous analytical, probabilistic, algebraic, geometric and computational mathematical techniques.	
Objectives: The aim of the course is to introduce the student to the principles and the methodologies of Analytical Mechanics and make the student familiar with the resolution of problems in Classical Mechanics. Starting from the Newtonian dynamics of a particle, we derive the Lagrange and Hamilton equations of motions. Moreover, we provide the formulation also in terms of variational principles.	
Propaedeuticities: **Is a propaedeuticity for:**	
Types of examinations and other tests: Written test and oral examination.	

Course: MATHEMATICS FOR CRYPTOGRAPHY	**Teaching Language:** English
SSD (Subject Areas): INFO-01/A	**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: Computer science is the science that deals with systems and processes computational and automatic processing of information and studies the foundational, methodological, technological, social and educational. The sector is interested in scientific and educational activities relating to the design, implementation, management and use of systems computer scientists. The skills concern the conceptual foundations and IT applications, used in various disciplines for problem solving using the computational approach. The sector includes cybersecurity (protection and privacy in the access and use of data, networks and systems; encryption; secure application design software and techniques for identifying risks; digital forensics).	
Objectives: The purpose of the course is to introduce the student to number theoretic topics, both ancient and very modern, which are at the center of interest in contemporary cryptography, especially in the most known public key cryptosystems such as RSA; an algorithmic approach is taken, emphasizing estimates of the efficiency of the techniques that arise from the theory.	
Propaedeuticities: **Is a propaedeuticity for:**	
Types of examinations and other tests: Written dissertation/oral colloquium.	

Course: MECHANICAL VIBRATIONS	**Teaching Language:** English
SSD (Subject Areas): IIND-02/A	**CREDITS:** **6**
Course year: II	**Type of Educational Activity: B**
Teaching Methods: 3 CFU in presence, 3 CFU MOOC (Massive Open Online Courses)	
Contents extracted from the SSD declaratory consistent with the training objectives of the course: The disciplinary scientific sector is interested in scientific activity and educational training in the field of Applied Mechanics Machines. Cultural, scientific and professional aspects are included and historians inherent to the study of mechanical systems, machines, their components and structures. The interests of the sector include vibrational phenomena, vibroacoustic and tribological, which are among the main focuses of the course.	
Objectives:	

The objective of the course is to provide the basic knowledge useful for modeling and analyzing the vibrational behavior of mechanisms, machines and groups of machines. To this end, both the aspects of motion transmission that cause the emergence of vibratory phenomena are explored in depth, through the study of the elements that influence the transmission itself, and the dynamic aspects deriving from the functioning of machines and groups of machines, with the aim to evaluate the extent of vibratory oscillations and to develop systems capable of modifying their nature and effect, in terms of amplitude, pulsation and phase.

Propaedeuticities:
Is a propaedeuticity for:

Types of examinations and other tests:
Oral examination.

Course: MODERN AND SOLID STATE PHYSICS	**Teaching Language:** English
SSD (Subject Areas): Module 1: PHYS-02/A Module 2: PHYS-04/A	**CREDITS:** **12** Module 1: MODERN PHYSICS 6 credits Module 2: SOLID STATE PHYSICS 6 credits
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:

Module 1:

The scientific-disciplinary sector is characterized by scientific research and educational activities focused on the theoretical and computational investigation of physical phenomena. These activities are based on fundamental or emerging principles and laws, utilizing appropriate mathematical and computational tools. The competencies cover areas such as quantum mechanics and its foundations, classical theories of gravitation, particle physics, and fundamental interactions. The activities within the sector include the study and development of mathematical and numerical methods in theoretical physics, aimed at the investigation, analysis, and construction of models for phenomena in both physical and interdisciplinary contexts.

Module 2:

Research activities characterize the scientific-disciplinary sector scientific and educational-training regarding theoretical investigation e computational knowledge of dynamic, thermodynamic and statistical phenomena of matter in all its states of aggregation, in conditions of equilibrium and non-equilibrium; the treatment of the properties of propagation and interaction of radiation and particle beams with matter; the knowledge necessary for the development of models theoretical, mathematical methods and numerical techniques, including first-principles and multiscale simulations; the study of aspects mathematical physicists of artificial intelligence and the development of algorithms of machine learning motivated by physics problems of the matter with its related applications, even in different fields interdisciplinary. The skills of the sector concern: mechanics quantum theory and its foundations, quantum information and computation quantum physics, classical and quantum statistical mechanics, phenomena critical and phase transitions, atomic and molecular physics, states liquid and solid, metallic, magnetic and strongly correlated systems, semiconductors and insulators, macroscopic quantum states,

disordered systems, materials science, low systems dimensionality, nanosciences and nanotechnologies, conversion and energy storage, thermomechanical properties, been diluted, gases, plasmas, as well as soft matter, active and biological. The sector's activities also include the theoretical study of acoustics, classical and quantum optics, photonics, quantum electronics and optoelectronics, quantum technologies, open systems, statistical, quantum and topological properties of matter, as well as non-linear physics, statistics and complex systems. Finally, sector expertise includes development of teaching and learning methodologies of matter physics, quantum mechanics, statistical mechanics, and their applications. In addition to that relating to the specialist disciplines congruent with this declaration, the teaching activity of those belonging to the sector extends to all institutional aspects relating to the teaching of general physics and basic classical and quantum physics, with the exception of experimental physics laboratory courses.

Objectives:

Module 1:

The course aims to provide an introduction to fundamental aspects of 20th century physics: special relativity, quantum mechanics, elementary particle physics, general relativity and cosmology**.**

Module 2:

Fundamental aspects of solid state physics. Phenomenological and microscopic description of metals and semiconductors. Transport, thermodynamic and dielectric properties of solids.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:

Oral exam

Course: NONLINEAR DYNAMICS AND CONTROL	**Teaching Language:** English
SSD (Subject Areas): IINF-04/A	**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 sector studies methods and technologies for information processing aimed at modeling, automatic control in real time, supervision, planning and management of plants, processes and dynamic systems in general. The approach offered allows to abstract from the particular application domain dynamic structural properties that can be represented through appropriate classes of mathematical models. This makes it possible to unify the methods for analyzing complex dynamic systems - artificial and natural - and designing control and management systems in order to give them forms of intelligence, learning, robustness, reliability and autonomy that ensure, even without direct human intervention, optimized programmed behaviors, adaptability, self-diagnosis of faults and restoration of normal operating conditions.

Objectives:

The course aims to introduce students to the fundamentals of analysis and control of nonlinear systems and to illustrate the most representative applications. The problems of consensus and coordination control of networks and complex systems will be introduced.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:

Oral examination and project discussion

Course: NONLINEAR SYSTEMS	**Teaching Language:** English
SSD (Subject Areas): IINF-04/A	**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 sector studies methods and technologies for information processing aimed at modeling, automatic control in real time, supervision, planning and management of plants, processes and dynamic systems in general. The approach offered allows to abstract from the particular application domain dynamic structural properties that can be represented through appropriate classes of mathematical models. This makes it possible to unify the methods for analyzing complex dynamic systems - artificial and natural - and designing control and management systems in order to give them forms of intelligence, learning, robustness, reliability and autonomy that ensure, even without direct human intervention, optimized programmed behaviors, adaptability, self-diagnosis of faults and restoration of normal operating conditions.	
Objectives: The aim of the course is to introduce students to the foundations of the mathematical theory of nonlinear systems of ODEs and to illustrate the theory via some representative examples from applications.	
Propaedeuticities: **Is a propaedeuticity for:**	
Types of examinations and other tests: Oral examination and project discussion.	

Course: NUMERICAL METHODS	**Teaching Language:** English
SSD (Subject Areas): MATH-05/A	**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:
In particular, the course: - Deals with the development, theoretical analysis, and experimental validation of numerical methods for linear algebra, approximation, optimization, and scientific computing. - It provides the common base on computational aspects of mathematics and applications in scientific, engineering, biomedical, economic, social, and cultural fields, including those related to data science, artificial intelligence, and the study of complex systems.
In particular, the main training objectives and tools are the following. - Numerical linear algebra: deterministic and stochastic numerical methods for linear problems with an emphasis on matrices of large dimensionality, and the solution of matrix equations. - Numerical approximation: Numerical Methods for the approximation and analysis of data, the approximation of operators. - Numerical Optimization: Numerical methods for the estimation of parameters of models from data, inverse problems and machine learning. - Scientific computing: Numerical methods for solving problems in applied sciences and technology, with the goal of extracting quantitative information from experimental data, simulating analyzing and controlling complex phenomena.

Objectives:
The course provides fundamental methodologies of numerical analysis, that constitute the basis for the numerical solution of many problems in science and engineering. Such methods provide also the basis of scientific machine learning. The course contains frontal lessons, computer laboratory and seminars. The syllabus of the course is the following: Introduction to Functional Analysis. Vector spaces, metric and normed spaces. Banach and Hilbert spaces. Fundamental Theorem of Linear Algebra. Least Squares Problem, Linear Ill-posed problems and Regularization. Real World Problems. Singular Value Decomposition. Proof of SVD theorem. Eckhart-Young-Mirsky Theorem. Proof. Real Problems-Data-driven analysis. The Moore-Penrose Pseudoinverse. Principal Component Analysis. Real World Problems. Linear Discriminant Analysis. Iterative methods for linear systems. The Power Method. The Richardson iteration. The Banach fixed point theorem. Banach Lemma and approximate inverses. Jacobi, Gauss Seidel iterative methods for large scale systems. Preconditioning. Theory of Projectors. QR factorization and Gram-Schmidt Orthogonalization. Cholesky Factorization. Iterative methods in the Krylov subspace. Conjugate Gradient, GMRES, ARNOLDI. Problems. Solution of nonlinear algebraic systems. Newton's method, Chord method. Newton’s GMRES. Introduction to Machine Learning and Artificial Neural Networks. The Backpropagation Algorithm and the Gradient Descent, Gauss Newton optimization algorithms. Applications to Scientific Machine Learning. Artificial Neural Networks. Gaussian Process Models. The forward and inverse problems in complex systems. Complex Systems and Numerical Analysis Algorithms.

Propaedeuticities:
Is a propaedeuticity for:

Types of examinations and other tests:
3-4 Problem/Projects Sets/Assignements. Final Oral Examination.

Course: NUMERICAL MODELING OF MATERIALS AND SOLID STATE PHYSICS	**Teaching Language:** English
SSD (Subject Areas): Module 1: CHEM-04/A Module 2: PHYS-04/A	**CREDITS:** **12** Module 1: NUMERICAL MODELING OF MATERIALS 6 credits

	Module 2: SOLID STATE PHYSICS 6 credits
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:

Module 1:

The disciplinary scientific sector is interested in scientific and educational - training activities in the field of science and technology for the sustainable industrial development of products, materials, chemicals processes and energy, through the definition of the principles and the study of thermodynamic, kinetic, catalytic and technological aspects related to them. The sector deals also with the chemical and technological properties of polymeric materials, their characterization and the understanding of relationships between structure and properties of polymeric materials.

In this frame, the course gives an introduction to numerical simulations methods aimed to understand the behaviour, the relationship between structure and properties and the thermodynamic properties of materials with special emphasis of polymeric and more in general soft materials. The main numerical techniques related to molecular simulations methods will be introduced. A list of the main topics is reported below:

-Introduction to thermodynamics and to the main features of polymeric materials
-Basics of Statistical Mechanics for Molecular Simulations
-Introduction to Molecular Simulations
-Molecular Dynamics and Monte-Carlo
-Force Fields
-Hands on Tutorials
-Some example applications
-Coarse-Graining Models

Module 2:

Research activities characterize the scientific-disciplinary sector scientific and educational-training regarding theoretical investigation e computational knowledge of dynamic, thermodynamic and statistical phenomena of matter in all its states of aggregation, in conditions of equilibrium and non-equilibrium; the treatment of the properties of propagation and interaction of radiation and particle beams with matter; the knowledge necessary for the development of models theoretical, mathematical methods and numerical techniques, including first-principles and multiscale simulations; the study of aspects mathematical physicists of artificial intelligence and the development of algorithms of machine learning motivated by physics problems of the matter with its related applications, even in different fields interdisciplinary. The skills of the sector concern: mechanics quantum theory and its foundations, quantum information and computation quantum physics, classical and quantum statistical mechanics, phenomena critical and phase transitions, atomic and molecular physics, states liquid and solid, metallic, magnetic and strongly correlated systems, semiconductors and insulators, macroscopic quantum states, disordered systems, materials science, low systems dimensionality, nanosciences and nanotechnologies, conversion and energy storage, thermomechanical properties, been diluted, gases, plasmas, as well as soft matter, active and biological. The sector's activities also include the theoretical study of acoustics, classical and quantum optics, photonics, quantum electronics and optoelectronics, quantum technologies, open systems, statistical, quantum and topological properties of matter, as well as non-linear physics, statistics and complex systems. Finally, sector expertise includes development of teaching and learning methodologies of matter physics, quantum mechanics, statistical mechanics, and their applications. In addition to that relating to the specialist disciplines congruent with this declaration, the teaching activity of those belonging to the sector extends to all institutional aspects relating to the

teaching of general physics and basic classical and quantum physics, with the exception of experimental physics laboratory courses.
Objectives: **Module 1:** The student will be familiar with the main techniques utilized in the field of molecular simulations and will have the basis to choose appropriate description of soft materials using these techniques. **Module 2:** Fundamental aspects of solid-state physics. Phenomenological and microscopic description of metals and semiconductors. Transport, thermodynamic and dielectric properties of solids.
Propaedeuticities: **Is a propaedeuticity for:**
Types of examinations and other tests: Report of a project and its oral presentation/Written and oral examination.

Course: OPERATIONAL RESEARCH	**Teaching Language:** English	
SSD (Subject Areas): MATH-06/A		**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: Operations Research deals with the development of quantitative models and methods for decision-making problems with the aim of analyzing, optimizing, planning and governing the behavior of complex processes. The skills and application research areas are related to the development of models and methods for the solution of decision-making problems that arise mainly: in the context of the design, organization and management of production systems for goods and services, such as planning and control, programming of activities, scheduling, resource allocation, project management, maintenance, logistics, transportation. All the different phases that characterize the decision-making process, even in conditions of uncertainty, are relevant aspects for the sector: definition of the problem, objectives and action alternatives and related mathematical formalization; study of the complexity of problems; development of exact, approximate solution algorithms, heuristics, metaheuristics; implementation, even on advanced architectures, evaluation and certification of procedures and solutions.		
Objectives: The main objective of the course is the introduction of the students to the use of mathematical programming models. Both linear and nonlinear optimization models (with both continuous and integer variables) are studied, and their applications in real-world fields, including communications, logistics, services, and industrial production. As concerns nonlinear programming models, the course aims at providing a comprehensive and rigorous treatment of classical topics, such as descent algorithms, Lagrange multiplier theory, and duality. In addition, some of the more sophisticated methods are also covered, such as interior point methods, penalty and barrier methods, least squares problems, and conditional gradient and subgradient optimization.		
Propaedeuticities: **Is a propaedeuticity for:**		

Types of examinations and other tests:
Written and oral examination.

Course: OPTOELECTRONICS	**Teaching Language:** English
SSD (Subject Areas): IINF-01/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 disciplinary scientific sector covers scientific research, teaching and training activities in the field of electronics. The sector includes theoretical, methodological and technologies necessary to conceive, design, build and test electronic and photonic devices, circuits, instrumentation and systems, aimed at: - generation, transmission, acquisition, processing, use and representation of signals; - control, operation and monitoring of equipment and systems; - generation, conversion, transformation, distribution, energy transmission and storage. Specialist activities of interest include micro- and nano-electronic devices; sensors, micro- and nano-systems and instrumentation; optoelectronics and photonics; analog and digital integrated electronic circuits; industrial and power electronics; microwave and millimeter wave electronics; electronic systems and their programming. The aforementioned specialist activities are used in numerous areas of fundamental and applied science. The teaching and training activities, in which the results of research in the sector are usefully reported, cover both basic concepts and specialized aspects, using electronics-specific approaches at all levels. The theoretical foundations, methods and technologies for designing and developing are included in the teachings of the sector and test electronic and photonic devices, circuits and systems, ensuring compliance with requirements, performance, reliability and sustainability.

Objectives:
This course is designed to provide an overview of integrated optics, from the system point to view. The course will present the basic concepts of integrated optics, including materials and fabrication technologies as well as the major integrated optical devices.

Propaedeuticities:
Is a propaedeuticity for:

Types of examinations and other tests:
Student will be evaluated on the base of an original Elaboration and Discussion on a pre-assigned topic, and oral examination on the course contents.

Course: PARTIAL DIFFERENTIAL EQUATIONS	**Teaching Language:** English
SSD (Subject Areas): MATH-03/A	**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:

Research in the Mathematical Analysis sector aims at the elaboration of rigorous and innovative methodologies for the analysis of problems that emerge both within mathematics and in applications to physical, natural, social and life sciences, computer science and to technological innovation. The sector includes a broad spectrum of skills and research fields among which: analytic theory of numbers, real analysis, theories of measure, integration and approximation, geometric theory of measure, complex analysis in one or more variables, harmonic analysis, functional analysis, algebras and theory of linear and nonlinear operators, ordinary and integral differential equations in finite dimension e infinite, dynamic systems, linear and non-linear partial differential equations linear, calculus of variations, mathematical theory of control and of games, inverse problems, variational methods and optimization, and covers finally, the analytical aspects of geometric theories. The sector also deals with developing innovative analytical methods for physical theories including classical, quantum and relativistic field theories, transport and diffusion theories, kinetic theories and fluid dynamics. Develops new analytical methods to place the study and validation of mathematical models for the life, economic and social sciences, engineering, IT and artificial intelligence in a rigorous framework, also in the light of numerical simulations and data analysis. The teaching skills concern, in addition to the topics set out above and the fundamental teachings of the sector, all the teachings relating to basic mathematics contents.

Objectives:

The first objective of the course is to provide the basic results on existence, uniqueness and qualitative properties of solutions of classical PDEs such as: Laplace, Poisson, heat, transport and wave equations; the second objective is to give the basic tools for solving explicitly in special cases the above equations using variables separations, series expansion, Fourier or Laplace transforms; the third objective is to provide a thorough introduction to Sobolev functions with the aim of accomplishing the fourth objective of the course, that is an introduction to weak solutions of a linear elliptic equation in divergence form and the corresponding existence, uniqueness and nonuniqueness, and regularity results.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:

Oral examination.

Course: REAL AND FUNCTIONAL ANALYSIS	**Teaching Language:** English
SSD (Subject Areas): MATH-03/A	**CREDITS:** 9
Course year: I	**Type of Educational Activity: B**

Teaching Methods:

6 CFU in presence, 3 CFU MOOC (Massive Open Online Courses)

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

Research in Mathematical Analysis aims at the elaboration of rigorous and innovative methodologies for the analysis of problems that emerge both within mathematics and in applications to
physical, natural, social and life sciences, computer science and to technological innovation. The topic includes a broad spectrum of skills and research fields among which: real analysis, measure theory, integration and approximation, functional analysis, theory of linear and nonlinear operators, linear and nonlinear partial differential equations, The sector also deals with developing innovative analytical methods for physical theories including classical, quantum and relativistic field theories, transport and diffusion theories, kinetic theories and fluid dynamics. Develops new analytical methods to place the study and validation of mathematical models for the life, economic and social sciences, engineering, IT and artificial intelligence in a rigorous framework, also in the light of numerical simulations and data

analysis. The teaching skills concern, in addition to the topics set out above and the fundamental teachings of the sector, all the teachings relating to basic mathematics contents.

Objectives:
The aim of this course is to provide students with basic knowledge of Real Analysis and Functional Analysis, particularly topics that are useful for the study of many other Mathematical Engineering courses.

Propaedeuticities:
Is a propaedeuticity for:

Types of examinations and other tests:
Tests in itinere and/or oral examination.

Course: STATISTICAL METHODS AND CHEMICAL PROCESS	**Teaching Language:** English
SSD (Subject Areas): Module 1: STAT-01/B Module 2: ICHI-01/C	**CREDITS:** **12** Module 1: STATISTICAL METHODS FOR INDUSTRIAL PROCESS MONITORING 6 credits Module 2: CHEMICAL PROCESS ANALYSIS AND SIMULATION 6 credits
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:
Module 1:
The scientific-disciplinary field is characterized by a specific focus on modern statistical issues in experimental sciences, particularly in engineering (reliability, statistical quality control). The main application areas concern technology, safety, environment, territory, production processes, products, and natural resources.

Module 2:
The disciplinary scientific sector is characterized by a systematic approach to the study of the chemical and physical processes and phenomena involved and is aimed at optimisation, control, management and digitalisation of industrial processes. The qualifying themes, both in scientific and educational-training activities, concern the development and application of methods mathematicians for the analysis and computational modeling of process industry systems; optimization and life cycle analysis methods; statistical and probabilistic methods for the analysis of data and trial programming, including machine learning and artificial intelligence tools; scale-up methodologies; methodologies for the study of dynamics and for the analysis and synthesis of control systems, also in relation to safety and process intensification. The applications concern the operational, energy, economic and environmental aspects of the chemical, biotechnological, food, pharmaceutical, energy industries, for the production, transformation and recycling of materials.

Objectives:
Module 1:
Statistical Methods for Industrial Process Monitoring is a methodological-applicative course whose aim is to train students on statistical tools for monitoring complex technological systems. Application (illustrated

through open-source statistical software environment R) of interpretable statistical techniques for decision-making, possibly scalable also up to big data frameworks. Teamwork on data-analysis projects developed along the course that are gathered from real-world industrial problems (problem-based learning). Students should improve their ability to recognize the most suitable mathematical space to immerge the data and statistical techniques to solve the problem at hand as well as the skill of communicating relevant results and the impact of the analysis also to non-statisticians.

Module 2:
The course will focus on the mathematical description of chemical and physical phenomena that occur in the process industry equipments.

Propaedeuticities:
Is a propaedeuticity for:

Types of examinations and other tests:
Written and oral examination.

Course: STATISTICAL METHODS AND ECONOMIC THEORY	**Teaching Language:** English
SSD (Subject Areas): Module 1: STAT-01/B Module 2: STAT-04/A	**CREDITS:** **12** Module 1: STATISTICAL METHODS FOR INDUSTRIAL PROCESS MONITORING 6 credits Module 2: ECONOMIC THEORY 6 credits
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:
Module 1:
The scientific-disciplinary field is characterized by a specific focus on modern statistical issues in experimental sciences, particularly in engineering (reliability, statistical quality control). The main application areas concern technology, safety, environment, territory, production processes, products, and natural resources.

Module 2:
The disciplinary scientific sector includes scientific and educational-training activity aimed at the identification and development of mathematical methods and tools, including calculation and data processing techniques, for the formulation and analysis of problems and models relating to management corporate; to economic and social sciences; to finance; to actuarial disciplines; to individual, strategic and collective choices; market analysis and risk management.The skills scientific-educational related to the topics indicated above include all those mathematical tools and methodologies, as well as calculation or data processing techniques, aimed at the study of economic, financial, actuarial, business or social science problems.

Objectives:
Module 1:

Statistical Methods for Industrial Process Monitoring is a methodological-applicative course whose aim is to train students on statistical tools for monitoring complex technological systems. Application (illustrated through open-source statistical software environment R) of interpretable statistical techniques for decision-making, possibly scalable also up to big data frameworks. Teamwork on data-analysis projects developed along the course that are gathered from real-world industrial problems (problem-based learning). Students should improve their ability to recognize the most suitable mathematical space to immerge the data and statistical techniques to solve the problem at hand as well as the skill of communicating relevant results and the impact of the analysis also to non-statisticians.

Module 2:
The course introduces students to a rigorous investigation of equilibrium concepts in microeconomic theory, including cooperative and non-cooperative solution concepts in general equilibrium models with uncertainty and asymmetric information.

Propaedeuticities:
Is a propaedeuticity for:

Types of examinations and other tests:
Written and oral examination.

Course: STATISTICAL METHODS AND SIGNALS THEORY	**Teaching Language:** English	
SSD (Subject Areas): Module 1: STAT-01/B Module 2: IINF-03/A		**CREDITS:** **12** Module 1: STATISTICAL METHODS FOR INDUSTRIAL PROCESS MONITORING 6 credits Module 2: SIGNALS THEORY 6 credits
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:
Module 1:
The scientific-disciplinary field is characterized by a specific focus on modern statistical issues in experimental sciences, particularly in engineering (reliability, statistical quality control). The main application areas concern technology, safety, environment, territory, production processes, products, and natural resources.

Module 2:

The disciplinary scientific sector brings together the skills that combine telecommunications methodologies with the design of complex interconnected systems in order to contribute to the development and evolution of information and communication technologies that characterize the "information society". The sector deals with the study and design of systems and services in the following areas: - acquisition, models and coding of real and synthetic multimedia signals (audiovisual, 3D and more); numerical processing and machine learning of signals for information communication, pattern recognition, semantic interpretation of information content; human-machine communication; - transmission of information with radio, optical and acoustic carriers. Modeling of communication systems. Modulation, synchronization and channel estimation. Source and channel coding. Multiple access techniques. Cognitive radio, cooperative systems, relay and multi-hop. Communication and sharing of large amounts of data. Molecular and quantum communications; - protocols and algorithms for the distribution, switching and transport of information on networks and systems, with reference to the entire protocol stack. Design, management and optimization of network and service infrastructures. Programmable and virtualized networks and sensor networks. Network aspects of IoT and cloud-edge; remote sensing technologies and systems for the acquisition of signals and images using sensors, including cognitive ones, for example optical and radar; processing, analysis, extraction and fusion of information for the detection, tracking and recognition of objects and people; terrestrial and satellite localization and navigation systems; - signal intelligence: encryption, marking, biometrics and forensic analysis; physical layer security; monitoring of telecommunications networks and systems; security of interconnection and representation in distributed systems. Typical teaching skills in the sector include: signal theory, theory of random phenomena, information theory, theory of detection and estimation, numerical signal processing, statistical signal processing, information transmission, telecommunications networks and systems.

Objectives:

Module 1:

Statistical Methods for Industrial Process Monitoring is a methodological-applicative course whose aim is to train students on statistical tools for monitoring complex technological systems. Application (illustrated through open-source statistical software environment R) of interpretable statistical techniques for decision-making, possibly scalable also up to big data frameworks. Teamwork on data-analysis projects developed along the course that are gathered from real-world industrial problems (problem-based learning). Students should improve their ability to recognize the most suitable mathematical space to immerge the data and statistical techniques to solve the problem at hand as well as the skill of communicating relevant results and the impact of the analysis also to non-statisticians.

Module 2:

The aim of the course is to provide the basic tools for the analysis of deterministic signals and for their processing using linear systems, both in the time and frequency domain. A further goal is to introduce the basic concepts of probability theory and random processes.

Propaedeuticities:

Is a propaedeuticity for:

Types of examinations and other tests:

Written and oral examination.

Course: STOCHASTIC PROCESSES	**Teaching Language:** English	
SSD (Subject Areas): MATH-03/B		**CREDITS:** 6
Course year: I	**Type of Educational Activity: B**	

Teaching Methods: 3 CFU in presence, 3 CFU MOOC (Massive Open Online Courses)
Contents extracted from the SSD declaratory consistent with the training objectives of the course: The sector includes theoretical and applicative skills related to Probability, Stochastic Processes and Mathematical Statistics. The skills cover foundational aspects of probability; probability on algebraic, topological and discrete structures; combinatorial probability; quantum probability; stochastic geometry; distribution theory; asymptotic theory; stochastic analysis; stochastic differential equations; random fields; Markov processes; special processes; rough analysis. The sector also deals with the development, study and application of rigorous stochastic models and probabilistic techniques underlying simulation methods in the socioeconomic, financial, biological, medical, engineering, physical and computer science fields. The teaching skills concern, in addition to the topics outlined above and the fundamental teachings of the sector, all the teachings related to basic contents of mathematics.
Objectives: The course intends to recover the basic knowledge of Probability theory (by making them more complete and rigorous) through the re-proposition, in a marked formalism, of fundamental contents. Concepts, contents and tools are provided, such as definitions, properties and theorems regarding conditional means, stopping times, martingale, Brownian motion, Markov processes and stochastic integration, which represent the basis both for a more in-depth study of the theory and for a conscious use in the applications of stochastic processes.
Propaedeuticities: **Is a propaedeuticity for:**
Types of examinations and other tests: Written and oral examination.

Course: SYSTEM IDENTIFICATION AND CONTROL	**Teaching Language:** English	
SSD (Subject Areas): IINF-04/A		**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 sector studies methods and technologies for information processing aimed at modeling, automatic control in real time, supervision, planning and management of plants, processes and dynamic systems in general. The approach offered allows to abstract from the particular application domain dynamic structural properties that can be represented through appropriate classes of mathematical models. This makes it possible to unify the methods for analyzing complex dynamic systems - artificial and natural - and designing control and management systems in order to give them forms of intelligence, learning, robustness, reliability and autonomy that ensure, even without direct human intervention, optimized programmed behaviors, adaptability, self-diagnosis of faults and restoration of normal operating conditions.		
Objectives:		

To endow the student of the ability to formulate and solve (analytically or numerically): i) parametric and Bayesian estimation problems, and ii) system identification problems with a focus on economic or financial applications.
Propaedeuticities: **Is a propaedeuticity for:**
Types of examinations and other tests: Oral examination.

Course: THEORY OF ELASTICITY	**Teaching Language:** English	
SSD (Subject Areas): CEAR-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 disciplinary scientific sector is interested in research activity scientific and educational-training inherent to all the classical themes and innovations in mechanics, both deterministic and stochastic, of materials, solids, structures and constructions, including their own historical development. In particular, the sector deals with development and dissemination of transversal methodological approaches and scientific tools innovative aimed at addressing problems related to: i) mechanical behavior of structural systems in the static context e dynamic (constitutive modeling, response to external actions, reliability, integrity, shape and topological optimization, experimental characterization), even in the presence of couplings multi-physics. ii) conception, testing, modeling, analysis and verification of civil engineering constructions, organisms or resistant elements e industrial, architecture and design, bioengineering and others applied sciences. The topics covered are specific to the theory of elasticity, linear and nonlinear (thermo-, aero-, pore-, chemo-, electro- and magneto-elasticity), as well as viscosity and plasticity, and include the statics, dynamics, stability of balance, active control and passive of vibrations, the mechanics of damage, of contact, of fracture and fatigue, calculation at failure, morphology and structural optimization. The methodologies and procedures developed, based on modeling physical and analytical, are typical of continuum mechanics, of computational and experimental mechanics, diagnostics and of static and dynamic structural identification, modeling, also through digital replication, of innovative structural forms and are aimed at the analysis, interpretation and solution of problems treated. The topics addressed extend to the aero-hydro-dynamic interaction between structures and physical environment with particular reference to models predictive of natural, climatic and anthropic risks, to the analysis of off-shore structures, vibrations of environmental origin, dynamics experimental, as well as theoretical aspects associated with monitoring and to structural vulnerability and theoretical aspects aimed at formulation of technical documents and codes of practice. The aforementioned themes start from the critical analysis of the historical development of models used, as well as from the structural reading of historical, monumental and cultural heritage artefacts, to extend to mechanics, local and non-local, of innovative, engineered materials and metamaterials, inorganic and functional materials present in biological systems, nano-, micro- and meso-systems, of unconventional structures, at all scales of observation and modeling.		
Objectives: The main objective of the course is to make the students get acquainted with the general concepts of continuum mechanics and to operatively apply them for the solution of basic problems in linear elasticity. The principal topics dealt with are Tensor analysis, infinitesimale and finite deformations; Lagrangian and		

Eulerian strain measures. Mechanical balance laws: Cauchy continuum and stress measures. Constitutive laws. Principle of material frame indifference. Variational techniques and finite element method.
Propaedeuticities: **Is a propaedeuticity for:**
Types of examinations and other tests: Oral examination.

Course: THERMODYNAMICS AND TRANSPORT PHENOMENA		**Teaching Language:** English
SSD (Subject Areas): IMAT-01/A		**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 disciplinary scientific sector is interested in scientific and educational-training activity in the field of Materials Science and Technology and in particular encompasses the complex of knowledge relating to materials of technical and engineering interest. Strongly characterizing the sector is the study of macroscopic properties and production processes.		
Objectives: The aim of the course is to introduce the main concepts of thermodynamics, and the concept of balance equation for momentum, energy and mass and their mathematical formulation in terms of continuum thermo-mechanics. Solving of basic problems for the description of transport phenomena will also be tackled.		
Propaedeuticities: **Is a propaedeuticity for:**		
Types of examinations and other tests: Oral examination.		

Course: WAVES		**Teaching Language:** English
SSD (Subject Areas): IIND-01/F		**CREDITS:** **6**
Course year: II	**Type of Educational Activity: B**	

Teaching Methods:
3 CFU in presence, 3 CFU MOOC (Massive Open Online Courses)

Contents extracted from the SSD declaratory consistent with the training objectives of the course:
The disciplinary scientific sector studies the motion of fluids with particular reference to applications in the engineering field. The research activities concern the study of fluids, Newtonian and non-Newtonian, in conditions of incompressible and compressible motion, also in the presence of thermal flows, reagents, multiphase and passive scalars, on a macroscopic and microscopic scale and in the bio-fluid dynamics field. Of interest are phenomenologies of stability and transition and dynamics of turbulence, generation of shock and interface waves, supersonic, hypersonic and plasma flows and interaction between fluid and bodies with aeroelastic and acoustic effects. A specific area is that of the design and fluid dynamic study of components, vehicles, turbines and devices, including bio-inspired, for the control of flows, in the context of sustainable mobility. The teachings of the sector concern the fundamentals of fluid dynamics, the main phenomenologies and technological applications in the aero- and gasdynamics, hydrodynamics and complex flows fields, the interactions of thermal, acoustic and baroclinic nature and the related theoretical, numerical and experimental methods.

Objectives:
The behaviour of water waves and the propagation characteristics of sound and light are familiar from everyday experience. This course accounts for the physical description and the underlying mathematical theory of various wave phenomenologies, with emphasis on unifying ideas.

Propaedeuticities:
Is a propaedeuticity for:

Types of examinations and other tests:
Oral examination.

ANNEX 2.2

DEGREE PROGRAM DIDACTIC REGULATIONS

MATHEMATICAL ENGINEERING

CLASS LM-44

School: SCUOLA POLITECNICA E DELLE SCIENZE DI BASE

Department: DIPARTIMENTO DI MATEMATICA E APPLICAZIONI R. CACCIOPPOLI

Didactic Regulations in force since the academic year 2025-2026

Training Activity: under Art. 10, c. 5, letter d	**Training Activity Language:** English	
Content of the activities consistent with the training objectives of the course: Additional language skills; IT and telematics skills; training and orientation periods.	**CFU:** **3**	
Course year: **II**		**Type of Training Activity: F**
Teaching Methods: in-person		
Objectives: Training activities contribute to the achievement of linguistic and/or computer-based and/or vocational training objectives for the world of work.		
Propaedeuticities: **Is a propaedeuticity for:**		
Types of examinations and other tests: aptitude		

ANNEX 3

DEGREE PROGRAM DIDACTIC REGULATIONS

CLASS LM-MATHEMATICAL ENGINEERING

School: SCUOLA POLITECNICA E DELLE SCIENZE DI BASE

Department: DIPARTIMENTO DI MATEMATICA E APPLICAZIONI R. CACCIOPPOLI

Regulations in force since the academic year 2025-2026

DOUBLE DEGREE – JOINT DEGREE

1. PREMISE

In this section, please provide a description of the Double Degree and/or Joint Degree, clearly explaining the scientific rationale for the Agreement and the period to be spent at the Partner University, including the specific number of semesters. Indicate the access modality to the program (e.g., public selection) and specify the annual application deadline.

This Double Degree regards the following diplomas:
• the Master's Degree of the University of Augsburg "Mathematical Analysis and Modelling",
• the Master's Degree of the University of Napoli Federico II "Mathematical Engineering",
• the Master's Degree of the University of Napoli Federico II "Mathematics",
• the Master's Diploma of the University of Rouen "Mathématiques et applications", parcours "Mathematical Analysis and Modelling" (MAM),
• the Master's Diploma of the University of Sevilla "Máster Universitario en Matemáticas" (Universitary Master in Mathematics),
• the Master's Diploma of the Tomsk State University "Mathematics", program "Mathematical Analysis and Modelling" (MAM).

The Agreement concerns the students of one of the partner universities enrolled in one the Master's programs listed above, who will follow the corresponding Master's program at one of the other universities. The students, who will pass the examinations, will be awarded two Master's diplomas, one at the home university and the other at the host university.

During the first year of the Master's program, students will study at their home university.
Students will carry on their studies according to the following schedule: the third or the third and fourth semesters will be studied at the host university.
The learning program at the host university during the mobility must be approved by the Steering Committee members of both home and host universities, and take into account the wishes of the student.
The language of instruction will be English as soon as necessary. It may be the local language if it is

commonly understood by all students.
The partner universities undertake to inform and support the first-year Master, Bachelor and Engineering students about the conditions of the Double Degree Agreement in an appropriate way.

2. NUMBER OF STUDENTS

In this section, indicate the number of students who can be able to join the program annually.
There are no restriction on the number of students who can be able to join the program annually.

3. REQUIREMENTS FOR ACCESS TO THE DD PROGRAM

In this section, list the requirements for access to the DD program, including the year of enrolment, the minimum number of CFU (university training credit), and linguistic knowledge certification.

Students must comply with the training and examination procedures existing at the home and host university.
The following rules apply:
- A student should have obtained a minimum of 45 ECTS at the home university to be accepted at the host university.
- In order to obtain a double diploma, a student must obtain 120 ECTS, with a minimum of 60 ECTS obtained at the home university, and a minimum of 15 ECTS obtained at the host university (in addition to 30 ECTS of the master thesis).
For the Master's thesis within the Double Master's Degree Programme, each student has two supervisors, one from the home university and the other one from the host university. The Master's thesis is written and is defended in English.
The Master's thesis defence takes place at the home or host university, after positive reports of two referees, one from the home and the other from the host university. The thesis defence is held according to the rules of the partner university where it takes place. The supervisor and, if requested, other members of the other university are invited to attend the defence, possibly by videoconference.

4. SELECTION CRITERIA

In this section, list the criteria, as agreed upon with the Partner University, that will be used to select candidates (e.g., degree grade, weighted average of exam scores, number of exams taken, etc.). Additionally, specify any additional requirements such as a portfolio, motivation letter, etc. Finally, indicate the selection criterion in the event of a tie.
A student who intend to join the Double Degree program should have obtained a minimum of 45 ECTS at the home university to be accepted at the host university.

5. FINANCIAL SUPPORT

In this section, the financial aspects should be specified. In particular, the method of financial support provided should be indicated (e.g., Erasmus grant).
Students who intend to join the Double Degree program can apply for Erasmus grant.

6. EQUIVALENCES TABLES

The determination of "equivalences" between the educational activities outlined in the Degree Program Didactic Regulations and those at the Partner University must meet two criteria: one formal and another substantial. Firstly, the DD/JD program must align with the "detail sheet of the degree program". Secondly, all educational objectives specified in the "detail sheet of the degree program" must be fulfilled (as per framework A4.a of the Annual single form of the Degree Program - SUA). These criteria can be addressed through an "individual" study plan specifically tailored for students pursuing the double degree (DD) or joint degree (JD). Therefore, it is necessary to define a table for each Partner University that documents the equivalences between the exams outlined in the Study Plan of the degree program and those at the Partner University/ies, based on these principles.
For constructing the table effectively, it is suggested to work on pathways that can be considered equivalent not individually but referring to the entirety of contents (knowledge and skills, including applied ones) conveyed by the courses within each Learning Area as compiled in Framework A4.b.2 of the SUA-CdS.
Please, refer to the examples of tables provided below (the first is suitable for study programs more closely related in terms of the distribution of disciplinary contents among courses; the second is suitable for study programs that have greater difficulty in identifying detailed correspondences between a UniNA course and a course at the Partner University) and the subsequent clarification regarding the Learning Areas of Framework A4.b.2 and their correct compilation:

Table: University of Augsburg, Germany

UNINA TEACHINGS		ECTS	Teachings at the Partner University		ECTS
Engineering disciplines	Computational Fluid Dynamics	9	Engineering disciplines	Software project	6
	Electrodynamics of continuous media	9		Control theory	9
	Optional*	6		Mathematical Modelling	9
Mathematical disciplines	Autonomously chosen topics	6	Mathematical disciplines	Advanced Seminar on Analysis	6
TOTAL ECTS		**n. 30**	**TOTAL ECTS**		**n. 30**

Table: University of Rouen, France

UNINA TEACHINGS		ECTS	Teachings at the Partner University		ECTS
Engineering disciplines	Computational Fluid Dynamics	9	Engineering disciplines	Basic Course of Asymptotic Statistic	6
	Electrodynamics of continuous media	9		Control and Optimization A	6
				Control and Optimization B	6
	Optional*	6		Scientific Calculus A	6
Mathematical disciplines	Autonomously chosen topics	6	Mathematical disciplines	Analysis of Partial Differential Equations A	6
TOTAL ECTS		**n. 30**	**TOTAL ECTS**		**n. 30**

Table: University of Seville, Spain

UNINA TEACHINGS		ECTS	Teachings at the Partner University		ECTS
Engineering disciplines	Computational Fluid Dynamics	9	Engineering disciplines	Statistical Data Mining	6
	Electrodynamics of continuous media	9		Optimization	6
	Optional*	6		Dynamical Systems	6
				Statistical Modeling and Prediction	6
Mathematical disciplines	Autonomously chosen topics	6	Mathematical disciplines	Functional Analysis	6
TOTAL ECTS		n. 30	TOTAL ECTS		n. 30

Table: Tomsk State University, Russia

UNINA TEACHINGS		ECTS	Teachings at the Partner University		ECTS
Engineering disciplines	Computational Fluid Dynamics	9	Engineering disciplines	Modern Methods of Data Mining	3
	Electrodynamics of continuous media	9		Statistical Analysis and Forecasting of Time Series	3
	Optional*	6		Multivariate Statistical Methods	3
				Methods of Spline Functions	3
				Industrial Mathematics	3
				Research	9
Mathematical disciplines	Autonomously chosen topics	6	Mathematical disciplines	Methods of Solving Ill-Posed Problems	6
TOTAL ECTS		n. 30	TOTAL ECTS		n. 30

Optional* Choice curriculum A - UNINA

COURSE	CFU	LEARNING AREA
Optoelectronics	6	Engineering disciplines
Electromagnetic Fields	6	Engineering disciplines
Information Theory	6	Engineering disciplines
Systems Identification and Control	6	Engineering disciplines
Waves	6	Engineering disciplines

Optional* Choice curriculum B - UNINA

Mechanical Vibrations	6	Engineering disciplines
Electromagnetic Fields	6	Engineering disciplines
Heat Transfer	6	Engineering disciplines
Analysis and Control of Complex Systems	6	Engineering disciplines
Nonlinear Dynamics and Control	9	Engineering disciplines
Environment Fluid Mechanics and Hydraulics	6	Engineering disciplines
Theory of Elasticity	6	Engineering disciplines

MATHEMATICAL DISCIPLINES (Framework A4.b.2 of the SUA-CdS)

Knowledge and understanding:

With reference to the field of mathematical disciplines, the student will acquire advanced mathematical methods such as:
- techniques for deducing mathematical models;
- analytical and numerical solution techniques for partial differential equations;
- numerical methods to solve problems inherent to the dynamics of gases, fluids and solids;
- theoretical and practical knowledge relating to the analysis of stochastic processes;
- optimization techniques.

Ability to Apply Knowledge and Understanding:

Appropriate activities will be planned as part of the courses, in particular during exercises and laboratory activities application of the knowledge acquired, through the analysis and study of model cases. The ability to selection of the mathematical model to use, appropriately measuring the desired accuracy and complexity tolerated, seeking a satisfactory adherence to reality but with careful consideration of costs. The verification the acquisition of contents, skills and scientific competences by students will, as a rule, be entrusted to the final exam of the courses. An important phase of maturation and evaluation of awareness critical in the use of scientific instruments will be the final test, in which students will apply the knowledge acquired in the plurality of attended courses to the same object of study.

Educational Activities through which knowledge and understanding capabilities are achieved and assessed:

ADVANCED APPLIED ENGINEERING MATHEMATICS
ALGEBRAIC STRUCTURES AND ADVANCED LINEAR ALGEBRA
ALGORITHMS AND PARALLEL COMPUTING
DIFFERENTIAL GEOMETRY
DISCRETE MATHEMATICS
GEOMETRIC STRUCTURES AND TOPOLOGY
MATHEMATICAL METHODS FOR ENGINEERING
MATHEMATICAL PHYSICS MODELS
MATHEMATICS FOR CRYPTOGRAPHY
MECHANICAL VIBRATIONS
MODERN AND SOLID STATE PHYSICS
NUMERICAL METHODS
OPERATIONAL RESEARCH
PARTIAL DIFFERENTIAL EQUATIONS
REAL AND FUNCTIONAL ANALYSIS
SOLID STATE PHYSICS *(modulo di MODERN AND SOLID STATE PHYSICS)*
STOCHASTIC PROCESSES

ENGINEERING DISCIPLINES (Framework A4.b.2 of the SUA-CdS)

Knowledge and understanding

Engineering knowledge will allow:
- the deepening of advanced knowledge regarding the mechanics of continuous media (in particular fluids), especially from the point of view of the specific numerical modeling simulation of their dynamic behaviour;
- the acquisition of knowledge of electrodynamics and electromagnetism, their modeling and simulation numerical in advanced applications;
- the in-depth study of the mechanisms at the nano- and mesoscopic scale that govern the behavior of matter and to chemical and physical transformations, and their modeling;
- the in-depth study of the dynamic behavior of free non-linear systems of engineering interest or in their interaction with control logics.

Ability to Apply Knowledge and Understanding:

The problem-solving attitude typical of an engineering education will be developed through examples of application of the methodologies taught to model cases and real cases. The teaching activities will be structured accordingly significant planning moments must be foreseen. As in the case of mathematical disciplines, the verification the acquisition of contents, skills and competences by students will be entrusted to the final exam courses, which involves the execution of practical exercises and often the evaluation of the projects developed as part of the course. In addition to attending institutional courses, an important opportunity to acquire critical awareness in the use of the scientific and technical tools used will be the preparation of the final thesis, during which the student will have to demonstrate not only the ability to develop an original paper of a relevant theoretical, experimental or planning nature to mathematics, industrial, information or civil engineering, but also to have acquired the ability to operate in autonomous way, mastery of the theoretical and technical tools used, which must be managed and analysed critically for the purpose of processing the data obtained.

Educational Activities through which knowledge and understanding capabilities are achieved and assessed:

ALGORITHMS AND PARALLEL COMPUTING
ANALYSIS AND CONTROL OF COMPLEX SYSTEMS
CHEMICAL PROCESS ANALYSIS AND SIMULATION *(modulo di STATISTICAL METHODS AND CHEMICAL PROCESS)*
COMPUTATIONAL FLUID DYNAMICS
ELECTROMAGNETIC FIELDS
ENVIRONMENT FLUID DYNAMICS AND HYDRAULICS
Electrodynamics of continuous media
HEAT TRANSFER
INFORMATION THEORY
MECHANICAL VIBRATIONS
NONLINEAR DYNAMICS AND CONTROL
NONLINEAR SYSTEMS
OPTOELECTRONICS
SIGNAL THEORY *(modulo di STAISTICAL METHODS AND SIGNAL THEORY)*
STAISTICAL METHODS AND SIGNAL THEORY
STATISTICAL METHODS AND CHEMICAL PROCESS
SYSTEMS IDENTIFICATION
TERMODYNAMICS AND TRANSPORT PHENOMENA
THEORY OF ELASTICITY
WAVES

The Degree program (CdS) identifies its **Learning Areas**, they are autonomously defined according to the first two Dublin Descriptors: "Knowledge and understanding" (knowing) and "Ability to apply

knowledge and understanding" (knowing how to do), referring to discipline-specific knowledge and skills acquired in specific fields and by-passing specific exams. The Learning Areas are chosen by the CdS in line with the educational project.

For each identified Area, it is necessary to list the educational activities (courses) activated in the reference academic year, which contribute to achieve the expected learning outcomes. The list of courses must be provided **annually**, considering that some courses may be newly activated, deactivated, offered every other year, or undergo changes in their denomination, among other possibilities.

Specifically, for each Learning Area, each Course has to specify:

Knowledge and Understanding:
i.e. expected learning outcomes with respect to disciplinary knowledge/competence and understanding (Dublin Descriptor 1), associated with the considered Learning Area.
Ability to Apply Knowledge and Understanding:
expected learning outcomes related to the ability to apply disciplinary knowledge/competence and understanding (Dublin Descriptor 2), associated with the considered Learning Area.
Educational Activities through which knowledge and understanding capabilities are achieved and assessed:
these activities include educational activities (i.e., courses) that contribute to achieve and assess the disciplinary knowledge/competence and understanding of the considered Learning Area. Each specific educational objective (Framework **A4.a**) should be reflected in the educational activities (grouped in Learning Areas of Framework **A4.b2**[1]). It is advisable to include hyperlinks to the Course Detail that describes the different aspects of the course (e.g., learning goals, course content, readings, teaching methods, examination/evaluation criteria).

7. STUDY PLANS TABLES DD - JD

Attention: The Equivalences Table does not concern all courses of the degree program but mainly those that the UNINA student must complete at the Partner University.
Please see the example below.

[1] Framework A4.b.2 connects three levels of detail:

- The **highest level**: where the Dublin Descriptors of each Learning Area of Framework A4.b.2 represent the basis of the overall synthesis presented in Framework A4.b.1 (which in turn connects with what has already been outlined in Framework A4.a).

- **The intermediate level**: where clusters of courses are gathered in Learning Areas, connecting through common cultural horizons, scientific paradigms, methods, and techniques.

- **The lowest level**: the Course detail designed to declare the expected learning outcomes, the methods of knowledge and skill transmission, and the methods of assessing acquired results. The Course detail represents the additional level of detail where clusters of courses finally differentiate from each other.

The tables show the exams that the UNINA student (and the student of the Partner University) must give for each year, specifying the location where they will be attended.

UNINA Student's I Year Path
As in the regular study plan UNINA, 63 CFU

UNINA Student's II Year Path – Partner University

I semester: Università Partner	CFU	II semester: Università Federico II	CFU
Training activities Engineering disciplines	9	Training activities Engineering disciplines	9
Autonomously chosen topics related to the modelling-application or advanced theoretical area	6	Autonomously chosen topics Engineering disciplines Mathematical disciplines	12
		Other topics	3
		Final test	18

Partner University Student's I Year Path
As in the regular study plan of the partner University

Partner University Student's II Year Path

I semester: Università Federico II	CFU	II semester: Università Partner	CFU
Training activities	9	As in the regular study plan of the partner University	24
Autonomously chosen topics related to the modelling-application or advanced theoretical area	6	Final test	18

Final test

For the Master's thesis in the Double Master's Degree programme, each student has two supervisors, one from the home University and the other from the host University. The Master's thesis is written and discussed in English. The defence of the Master's thesis takes place at the home or host University, after positive reports from the two reviewers, one from the home University and the other from the host University. The defence of the thesis is conducted according the rules of the partner University where it takes place. The supervisors and, if requiested, other members of the other University are invited to attend the discussion, possibly via videoconference.