International Master Degree in Management Engineering

Table 1 – Qualification profiles and learning objectives of the Course of Study

The International Master Degree in Management Engineering (Laurea Magistrale Internazionale in Ingegneria Gestionale) prepares the following professional profiles in a work context and roles in business organizations, enhanced by the coherent choice of available elective courses:

RM1 – Designer and manager of traditional and advanced production systems

Professional who takes technical and economic decisions relevant to the setup of production capacity and, in the production phase, to the efficient management of the factors of production. It is responsible for decisions on the technologies to be used, the level of automation of the production processes, the sources of energy supply, and the environmental impact of the process and the product. It integrates the various factors with systems engineering methodologies from a system life cycle perspective.

RM2: Innovation manager

Professional who supports - working directly with entrepreneurs, general managers, country managers - the identification of new business opportunities (blue ocean), using innovative approaches to explore and ideate new solutions (design thinking, user-centered design, lean canvas, business model canvas).

RM3 – Service Manager

Professional who conceives, designs, engineers, and/or streamlines service processes, operating in traditional service companies (banks, insurance companies, health care companies, public administrations, professional firms, etc.), or in manufacturing companies offering services to support their products along the life cycle, or in companies offering integrated product-service solutions (Product Service System).

RM4 – Project Manager

Professional who manages nonrepetitive activities concerning the realization of a tangible or intangible product, with a finite time horizon, characterized by resource, time, and precedence constraints. He/she places special emphasis on time, cost, quality, and risk control, operates in many different contexts, and can be the subject of specific professional qualifications.

RM5 – Operations and Supply Chain Manager

Professional who analyzes, plans, schedules, and controls production and supply chain following the paradigms of agile and lean production. He/she streamlines and simplifies production by identifying waste and detecting its root causes and best integrates production needs with those of maintenance, safety, quality, energy efficiency, and environmental impact reduction. In addition, he/she implements mechanisms for coordination and integration among the various actors of the supply chain.

RM6 – Reliability, Availability, Maintenance and Safety Engineer

Professional with the skills for measuring, assessing, managing, and improving RAMS (Reliability, Availability, Maintainability, and Safety) performance of components, systems, processes, plants and facilities. He/she is familiar with diagnostic methodologies aimed at optimizing maintenance activities; selects maintenance policies by minimizing expected cost, optimally manages spare parts inventory, performs risk and functional safety assessments, and identifies solutions for prevention and impact minimization.

Knowledge and understanding

The competencies identified for the above listed roles are embodied in the following knowledge and comprehension skills, which extend and reinforce those typically trained with a first level degree and enable the development and application of original ideas:

cc1: Stemming from an adequate knowledge of mathematical and statistical principles and an understanding of the role of mathematics as a tool for analyzing and solving problems and models underlying engineering, the student acquires knowledge of the design of experiments and the ability to plan an experimental design in an industrial setting from a robust design perspective, with subsequent statistical modelling and optimization; knowledge and the ability to apply statistical methods of prediction, modelling techniques and analysis of production systems and more generally of dynamic systems, including those in a stochastic regime, are developed..

cc2: Stemming from a sufficient knowledge of physical and chemical sciences and thermodynamics applied to energy systems, the understanding of the role played by different energy technologies in ensuring the environmental and economic sustainability of production will be enhanced.

cc3: Stemming from the knowledge of the technologies and industrial resources for production (machinery and equipment), and the principles of economics and organization of factors of production, this knowledge will be expanded and the understanding of the similarities and specificities of services will be developed.

cc4: Knowledge of RAMS (Reliability, Availability, Maintainability and Safety) principles and Risk and Safety assessment and management techniques will be developed; knowledge of diagnostic methods to support maintenance activities will be acquired as well.

cc5: Stemming from an understanding of information technologies and the role they play in supporting operations and business (IT-OT), knowledge of information technologies (hardware and software) for automation of production processes, their control and regulation will be acquired.

cc6: Knowledge will be gained of methods for innovation driven by new technologies (experimentation, rapid prototyping, open innovation) and driven by needs and new business opportunities (user-centric design, design thinking, ethno-graphic analysis, customer journey, empathy maps, personas model).

cc7: An understanding of the broader multidisciplinary context of engineering will be developed through a problem-solving approach, starting with the problem and tracing back to the typically multidisciplinary causes and possible measures to address them.

cc8: An understanding of applicable techniques and methods and their limitations will be developed.

cc9: The student will develop an awareness of the non-technical implications (ethical, legal, social, economic, environmental) of engineering practice.

Knowledge and understanding skills are developed essentially by traditional teaching tools, such as lectures and personal study on scientific texts and publications for the preparation of examinations and the final thesis paper.

Verification of the attainment of the learning objective is achieved by examinations with mainly oral content and by final and in-itinere written tests in the form of closed-response tests, as well as by the evaluation of the final thesis paper by the graduation committee.

In the definition of knowledge (cc7), (cc8) and (cc9), it is not the knowledge specific for the subject that is considered relevant, but rather a view of subject topics from the perspective of problem solving, the concrete applicability of specific principles and methodologies, and the complexity of management engineering problems, which are not exclusively technical and economic in nature. As such, when designing the content and methods of each course, the faculty members involved are urged to offer their subject matter with a slant that takes these elements into account.

Applying knowledge and understanding

The 'knowledge' enunciated above must lead to an ability to apply knowledge and understanding, i.e., a 'know how,' even in relation to new or unfamiliar topics, in broader and interdisciplinary contexts than one's own field, as articulated below:

ca1: The student will deploy the ability to choose and apply appropriate analytical and modelling methods, and in particular mathematical analysis, operations research modelling or practical experimentation supported by statistical

methods; the ability to use stochastic simulation; in particular, these skills are developed in experimental learning, possible laboratory activity and the production of design reports.
ca2: The student will develop the ability to apply his or her knowledge and understanding to identify, formulate, and solve industrial and, specifically, management engineering problems, defining specifications, technical, as well as social, health and safety, environmental, and business constraints, and to address them using established methods. Each discipline taught includes time for practice and practical application of the methods learned. The characterizing disciplines must develop the multidisciplinary skills required for the engineer.
ca3: The student will gain the ability to apply his or her knowledge and understanding of technologies, systems and plant, and possibly design processes, to analyze engineering products, processes, and methods.
ca4: The student will be able to choose and use appropriate equipments, tools and methods for the production of goods and services, even in the highly innovative context of the fourth industrial revolution (I4.0), digitization of processes, and the advent of new paradigms of production and consumption.
ca5: The student will be able to combine theory and practice to solve engineering and organizational problems, in complex contexts characterized by stochasticity, in the presence of incomplete or conflicting specifications, using statistical survey and inference tools, data mining and machine learning.
ca6: The student will be able to critically evaluate and interpret RAMS performance of even complex systems and facilities. Ability to identify the best design choices aimed at improving RAMS performance, use decision support tools, evaluate and interpret safety levels and risk indices.
ca7: The student will develop his or her ability to combine theory and practice to solve multidisciplinary engineering problems, taking into account constraints, including non-technical ones.

The ability to apply knowledge and understanding is essentially developed with the experimental teaching tools, such as exercises, assisted laboratory activity, classroom simulations, case discussion, role playing, serious gaming (e.g. Lego Serious Play) This ability must be demonstrated in the preparation, especially in an autonomous form, of design reports in the broad sense, possibly required by the single course. Final demonstration moment of the application skills can also be the final thesis work, especially when it has mainly design content and not a speculative one. An important role is played by the internship or placement activity, which can be carried out in companies and external institutions, or in public and private research laboratories, including those of the course of study.
Achievement of the learning objective is demonstrated by passing the examination tests based on written assignments (not in the form of closed-response tests), the oral interview, and in the evaluation, where applicable, of laboratory and project activities. A more general verification of achievement is in the evaluation of the final thesis by the graduation committee. For experimental classroom training activities, verification is generally not formal in nature, but provides feedback to the instructor on the effectiveness of the training tools in relation to the response of the classroom as a whole. Achievement of the objective in internship and placement activities is verified on the basis of the appropriate report provided by the tutor.
With similar motivations and objectives as for knowledge (cc7), (cc8) and (cc9), capability (ca2) should be interpreted, as it highlights the interdisciplinary nature of the problems, prompting teachers to collaborate among disciplines or to integrate their themes into their own exercises. Capabilities (ca3) and (ca4) are again related to the role of the management engineer, who is rarely used as a designer and more often as a decision maker, applying his or her knowledge in analyzing and choosing solutions, which can be traced back to the themes of numerous disciplines. Capability (ca7) also is not related to teaching but represents the multiobjective, multi-criteria approach to complexity, which the management engineer must have.

Making judgements

The Master of Science in Management Engineering degree program at the University of Florence is designed for students to gain the ability to integrate knowledge and manage complexity, as well as to make judgments based on limited or incomplete information, including thoughtfulness about the social and ethical responsibilities associated with the application of their knowledge and judgments.
In fact, students:
- mature the ability to identify, locate and obtain required data (ct10);
- have the ability to design and conduct analytical investigations, through the use of models and experimental techniques
- have the ability to interpret data drawn from reality or from computer simulations (ct10), as they receive the modelling, computer and statistical foundations in special courses and are required to use them in experimental laboratory activities;
- have the ability to critically evaluate data and results and draw conclusions (ct5).

Autonomy of judgment is developed through activities that require the student to make a personal effort, such as the production of an independent paper, in individual courses or for the final exam, but it is also implemented in those group activities, such as classroom simulations, role playing, and laboratories, where individuality and leadership skills can emerge from the dialectic among participants.

Achievement of the training objective is demonstrated by passing oral or written examinations in the form of an essay or design report in the broadest sense. Verification of goal attainment for experimental classroom training activities is generally not producing an official mark.

Communication skills

The Master of Science in Management Engineering program at the University of Florence is designed for students to be able to clearly and unambiguously communicate their conclusions, as well as the knowledge and rationale behind them, to specialist and non-specialist interlocutors.
Specifically, the student:
- improves his or her ability to work effectively individually and as a member of a group (ct2); in particular, the skills of leading and coordinating a group, which are characteristic of the project manager, are developed;
- improves his or her ability to present in written (ct1) or verbal (ct3), possibly multimedia (ct4), form his or her arguments and the results of his or her study or work; the final exam, in particular, is structured to asses this ability, but presentations of the results of his or her work may also be included in the tests of individual courses;
- demonstrates an adequate level of English language proficiency both in understanding sources and in communicating one's ideas (ct1), all courses being taught in English; in anticipation of being able to work and communicate efficiently in an international context, even the final thesis work will normally require in writing and presentation the use of English, according to the standards of international scientific-technical communications (ct6).
- Interpersonal communication skills are developed in participation in assisted laboratory activities, mainly organized in groups, as well as in experiential learning activities such as classroom simulation, role playing and case discussion.

Public communication skills are developed in making presentations of the project papers (ct1, ct3), where planned, with possible multimedia aids (ct4), and especially in the final examination.
Experience abroad and internship activities, moreover, are topical moments for the development of communication skills.
Verification of the achievement of the objectives consists of the examination evaluations, where the presentation of the results is an essential part of the examination paper, as well as the overall evaluation of the candidate in the degree examination by the committee. The interpersonal skills gained during internships and apprenticeships are highlighted in the appropriate reports prepared by the tutors prescribed.

Learning skills

The Master of Science in Management Engineering program at the University of Florence is designed for students to develop those learning skills that will enable them to continue studying mostly self-directed or autonomously.
The student in fact:
- coping with a constantly evolving subject matter, he or she recognizes the need for lifelong autonomous learning and matures the ability to engage in it; in fact, the internship activity is the first significant moment in which the student must demonstrate autonomy of initiative and implementation of his own knowledge, placed in front of real problems, not prepared for him for learning purposes.
- he or she is put in a position, through the higher knowledge and skills acquired, to profitably pursue the third level of university studies, with attendance at professional master, possibly after work experience, and Doctoral Schools, in order to dedicate himself or herself to university or industrial research.

The ability to learn in mainly guided form is developed in the preparation of oral examinations, writing design papers and reports. It is, however, in the writing of the thesis paper for the final examination, especially if done during an internship or placement, that the student develops and demonstrates independent learning skills (ct7).
Verification of the achievement of the objective is linked to the profit results in traditional teaching, and to the special reports of the tutors provided for internship and placement activities.
Autonomous learning, moreover, must be developed so that the student, in the absence of some of the prerequisite or curricular requirements for the subjects to be covered in the degree, can make up the deficit in knowledge and skills efficiently and effectively (ct9).

Table 2 – Learning objectives of main courses

Courses which are mandatory in every curriculum			
Course title	SSD	CFU	Learning objectives
PROJECT MANAGEMENT	ING-IND/17	6	The course contributes to the relevant definition of the professionalism of the RM4 (Project Manager) figure by providing the necessary elements for project management considering the different areas involved: the initial phase of preparing and negotiating the business proposal, defining the project scope, cost budgeting, project scheduling, project budgeting, project cash flow analysis, and risk identification and management. Skills will also be provided to manage the project with IT tools by tracking its progress, reviewing costs, time and risks, and taking expediting actions. The delivery of system engineering concepts and methods in the preliminary project phases also complements the RM1 (Traditional and Advanced Manufacturing Systems Designer and Manager) figure, while the ability to coordinate the execution of multiple projects that share resources will enrich the skills of the RM2 (Innovation Manager) figure and, with a view to introducing continuous improvement projects, the RM5 (Operations and Supply Chain Manager) figure. In particular, project control techniques during execution based on the concept of earned value are introduced. The project topic is treated by integrating technical, contractual, organizational and economic/financial aspects. Finally, some basic elements for the evaluation of research and development projects will be provided. Through lectures and exercises, students are asked to define the characteristics of a project, know the methodologies necessary for its management, choose the IT tools to support project management, organize and plan the activities of a project, and finally control the time and costs of a project. These skills go to increase understanding skills related to the broader context of engineering oriented to a problem solving approach (cc7), starting from the problem to trace back to the causes and possible measures to address them, typically multidisciplinary. Students will then be led to increase knowledge related to the understanding of applicable methods and techniques and their limitations (cc8) and eventually gain awareness of the non-technical implications of engineering practice. From a transversal skills point of view, it will involve group work aimed at the realization of design papers also with the help of multimedial tools (ct1, ct2, ct3, ct4). These activities will be aimed at developing independent judgment, analysis of international regulations and synthesis skills (ct5, ct7, ct10, ct11).
SUPPLY CHAIN MANAGEMENT	ING-IND/17	6	The contents of the course are transversal and relevant to many roles envisaged by the master degree, in particular, this course contributes to defining the professionalism of the RM5 (Operations and Supply Chain Manager) role in a relevant way, and contributes

			to the training of the RM1(designer/manager of advanced manufacturing systems. At the end of the course, the student should have acquired the main knowledge related to the structure and operation of a supply chain, in terms of: logistic processes and actors involved; flows; influence of decision-making choices on key performance (cc1, cc6, cc7 and cc8). The student should be able to independently design the supply chain and main processes, defining the most appropriate management policies in relation to the application context. By way of example, but not limited to, the student will be able to build a logistics network, decide on criteria for inventory allocation in the distribution system, measure the main logistics service indicators, deal with make or buy decisions in logistics, etc. The student should be able to use the acquired knowledge to analyze and process data to support related decision-making choices. The student should be able to evaluate the impact of strategic, planning and operational decisions on supply chain performance. The student should acquire the specific vocabulary inherent in supply chain and supply chain management. It is expected that, upon completion of the course, the student will be able to convey, in oral and written form, including by means of numerical problem solving, the main contents of the course (e.g., supply chain, supply chain management, agility, resilience, customer service, etc.), as well including the use of tools commonly used in the industry, such as block diagrams or flowcharts. The student will be able to deepen his or her knowledge of supply chain management in general through autonomous consultation of specialized texts, scientific journals, even outside the topics covered strictly in class (ca1, ca2, ca3 and ca4).
OPTIMIZATION AND INNOVATION OF PRODUCTION PROCESSES	ING_IND/16	9	The general objective of the course is to provide the competencies required for a manager of manufacturing processes (RM1) with special focus on the technological issues, the selection of the optimal processes and the economic impact of the possible technical alternatives. The course wants to provide the theoretical tools to analyze a manufacturing process and to define the optimal technical options both in terms of processes (cc3) and materials. This will be achieved thanks to the modelling of processes based on their physics (cc1, cc2) and the use of the tools to evaluate the possible introduction of innovative technologies such as rapid prototyping and Additive Manufacturing (cc6). The acquired competences will be applied in the development of a Design for Manufacturing analysis of a mechanical component, in order to test and refine what acquired on the optimization of a product design and its manufacturing cycle (ca3, ca4). This study will be carried out by groups of students (2-4 students for each group) and will enable the students to test their

			problem solving attitude (cc7) and to work within a team to create a technical-economic analysis of a product (cc9) using consolidated industrial approaches (cc8). Other competences that will be provided within the course are related to innovative and non-conventional processes (ca7), the analytical modelling of manufacturing processes (ca2) and the development of advanced monitoring solutions (ca2, ca3). The course requires the development of a reengineering study of an existing assembly, to be carried out by a team of students. The work must be presented by the group as part of the examination and it has the objective to support the acquisition of the following competences: written technical communication (ct1), coordinated group work (ct2), development of an adequate expression and technical discussion of own arguments (ct3), graphic representation and communication (ct4) and communication through presentations and web systems (ct8).
SYSTEM RELIABILITY, DEPENDABILITY AND SAFETY	ING-INF/07	6	The overall objective of the course is to provide the skills necessary for the role of a Reliability, Maintainability and Safety Engineer (RM6). Specifically, the course will provide the knowledge of RAMS (Reliability, Availability, Maintainability and Safety) principles and techniques for assessing and managing Risk and Safety; knowledge of diagnostic methods that also support maintenance activities (ct5, ct6) (cc4). The student will be able to conduct reliability design analyses with probabilistic models, estimate reliability parameters basing on historical and diagnostic data on machines and plants, and build complex inductive fault estimation models (ct3, ct4, ct5, ct10, cc7, cc8). Ability to critically evaluate and interpret RAMS performance of complex systems and plants (ca2, ca3, ca4) will be developed. Ability to identify the best design choices aimed at improving RAMS performance (ca7). Use decision support tools. Assess and interpret safety levels and risk indices (ct5, ct6, ct10, ca6).
OPTIMIZATION AND DATA SCIENCE FOR MANAGEMENT	MAT/09	9	The course presents advanced optimization methods and models oriented towards applications relevant for management engineering and in particular for optimized production planning, organization, prescriptive analytics models. The contents of the course are transversal and relevant for many roles included in the degree project. In particular, a production manager (RM1) will learn data science techniques for the development of predictive models, Service Managers (RM3) will learn advanced methods for optimal resource management, Operations and Supply Chain Managers (RM5) will learn advanced methods for production planning. The knowledge provided will be the following:

			Starting from a solid basic mathematical background the course will develop knowledge in the fields of and optimization theory and methods, both discrete and continuous (cc1) and in the field of machine learning for automatic classification (cc1). In these areas applied aspects will be studied in the context of management engineering (cc7); moreover, through laboratory sessions (ca1), the applications of what presented in the course will be critically analyzed (cc7, cc8). Students will be able to combine theory and practice for engineering and organizational problems, in complex contexts and will be able to use some data mining and machine learning tools (ca5). In general, the operational research approach presented in the course will be oriented towards the development of the ability to use theory, algorithms and practical experience to solve multidisciplinary problems (ca7) Students will be asked to explain both in written (ct1) as well as in verbal (ct3) form what learned; moreover they will be asked to present the result of a computer project work (ct4) through which they will be analyzing real data (ct10) and evaluate the conclusions of the analysis (ct5). Part of the course will be offered in flipped mode, so that students will be requested to practice with self-learning, followed by in class discussion (ct7). Most of the course material will be in English, so that an adqueate knowledge of the language will be required (ct11).
STATISTICS FOR EXPERIMENTS AND FORECASTS IN THE FIELD OF TECHNOLOGY	SECS-S/03	9	STATISTICS FOR EXPERIMENTS IN THE FIELD OF TECHNOLOGY (6 CFU) The goal of the course is to develop knowledge and abilities in order to analyse data through statistical models, by considering peculiar issues of the basic statistics, with a focus on the technological field. The student will be able perform an efficient experimental planning, to optimize a product or a production process with respect to specific characteristics (target) of quality and/or reliability (cc1, ca1). The latter also considering the phenomenon under investigation, the real context (external source of variabilities, noises). The possible decisional and technical implications (cc7) are also considered. The student will understand capabilities and limitations of the methods (cc8) in order to suitably join theory and practice (ca5) through the application of the theory to real data, and correctly exploiting the potentialities of the methods with respect to the environment and the process to be studied (ct5, ct10). The student will develop own abilities, starting from the design planning step, up to the final optimization step, by also considering the robust process optimization (ct7). The aims if also to develop analytical and critical abilities, so as to try refinements or explore different methodologies depending on the characteristics of the data (self-learning) (ct5, ct7) FORECASTING METHODS (3CFU)

			The goal of this module is to develop knowledges and abilities to make predictions, under uncertain conditions, using time series data (cc1, ca1). The phenomenon under investigation, the applied context and the possible decisional implications (technical – cc7 and not – cc9) are also considered. The student will understand capabilities and limitations of the methods (cc8) so as to link suitably theory and practice (ca5; ct5, ct10). The student will develop judgment and communication abilities, also using English (ct1, ct3, ct6). He will also develop analytical and critical abilities, so as to try refinements or explore different methodologies depending on the characteristics of the data (self-learning) (ct5, ct7).
LEADERSHIP AND PEOPLE MANAGEMENT	no SSD	3	The course aims to provide the fundamentals for people management in complex multi-cultural and cross-country organizations. It covers the processes of selection, recruitment and on-boarding, appraisal, enhancement and career management, well-being, reward and work-life balance. Topics are addressed with the right combination of theory and practice (ca8), with the use of testimonials by HR directors of large companies. This fosters the development of awareness of the non-technical implications of the engineering practice of industrial enterprise organization (cc10). Moreover, the course aims to facilitate leadership development in engineering students by creating contexts for the refinement of conceptual and operational tools to achieve better performance as a result of managing relationships in work teams ("achieve results through others"). For this, didactic tools of role play and simulation will be used, including performing in teams (ct2), where students will be asked to practice and improve their skills of expression and argumentation (ct3). Students will also be asked to select, engage and interview managers on the topics of interest. This will enable them to hone their desk and field research skills on technical and scientific information sources (ct6) and in producing and sharing concise written reports (ct1).
Courses which are mandatory in “Smart Industry” curriculum			
Course title	SSD	CFU	Learning objectives
INDUSTRIAL ASSET MANAGEMENT	ING-IND/17	6	The goal of the course is: - understanding and knowing how to assess the consistency between the production process and the type of product, identifying the critical factors for the management relating to the design and management of production plants (cc3, widening of knowledge in the technological and managerial field, and use of factors of production); - knowing how to define a system for measuring the technical performance of a production plant and it’s engineering assets, to be used for diagnostic purposes (cc3 measurement of factor productivity performance, cc4 specific measures of reliability, dependability, availability, maintainability). Knowing the information

			systems' portfolio and its role in operation management in order to find the information pieces needed to assess the technical performance of a production plat(cc5); - knowing the main maintenance philosophies, their strengths and weaknesses, their applicability and their economic optimization; - developing Reliability Centered Maintenance and Total Productive Maintenance competencies, total quality concepts applied to maintenance (cc4, ca6 capacity to critically evaluate the performance of reliability, dependability, availability, maintainability); - knowing how to model operations with tools such as queueing theory, the Montecarlo method (ca5, stochastic modeling and uncertainty). In the most applicative part the course develops the ability to select the most appropriate modelling methodology (ca4, choose and utilize for goods and service production appropriate tools and methods) and among these the ability to use event simulation, in order to develop design and reengineering solutions for plants and their management (ca1, stochastic simulation, ca5, ca7 solution of industrial problems in the presence of constraints not only technical). In addition to the specific learning objectives of the subject, the course aims to develop and consolidate the following transversal comprehension skills, such as: understanding the interdisciplinary nature of management engineering problems, with the need for a problem- solving approach, which starts from the problem for tracing the causes and possible countermeasures to address them (cc7); an understanding of the techniques and methods applicable in relation to their potential and limits (cc8). The transversal skills of applying knowledge and understanding will also be developed, such as: understanding of technical standards, in particular in the area of maintenance, productivity performance and levels of company information systems (ct5B071); the ability to identify, locate and obtain data and information necessary for assessment(ct10B233); the ability to critically evaluate data and results and draw appropriate conclusions, aware of the degree of uncertainty that could affect them(ct10B233); the advanced ability to operate effectively, individually and as members of a group(ct2), coordinating personal activities and responsibilities with respect to intermediate objectives and deadlines(ct7B071), having clear the context of the engineering problem and the interdisciplinary implications that distinguish industrial engineering(cc9); the ability to present in written(ct1), verbal and, possibly, multimedia form, its own arguments and the results of its study or work, with characteristics of organic unity and technical rigor(ct3, ct4, ct8B071); the adequate ability to locate and understand bibliographic and technical sources in English(ct5B233, ct6B071); the ability to reach adequate preparation to be able to access the third level

			of university studies (attendance at second level professional masters and doctoral schools), in order to further deepen knowledge and skills in the field of research.
OPERATIONS MANAGEMENT AND LEAN PRODUCTION	ING-IND/17	6	The course aims to provide students with the necessary knowledge to enable them to properly manage the production activities of manufacturing systems ("Operations Management"), with particular reference to Lean Production techniques. With reference to the engineer's occupational roles, these skills form part of the essential background of the designer and manager of traditional and advanced production systems (RM1), and of the Operations and Supply Chain Manager (RM5). The knowledge provided is: Starting from a solid knowledge of production systems, the theme of the design of production activities will be deepened, developing the ability to understand the advantages and limitations of organizational and plant choices in different contexts of application (cc3). In this context, the aspects of correct balancing of production lines, better known by the definition of Simple Assembly Line Balacing Problem (SALBP), will be examined in depth, arriving at solving concrete problems (ca2) in the context of management engineering (cc7). Moreover the problems of continuous improvement will be addressed, addressing them with the "Lean Production" approach applied to production systems (cc3) in a multidisciplinary context (cc7) in which it will be necessary to combine a technical understanding (cc8) with the ability to manage social, relational and economic problems (cc9). The student will be able to apply his or her skills to production plants (ca3), solving problems with a multidisciplinary approach (ca7). Regarding transversal skills, it is necessary for the student to know how to manage his or her own time and meet deadlines (ct7), interacting in exercises with a working group (ct2), facing problems through simulation (ct5, ct10). The exercises involve the preparation of written papers (ct1), in English (ct11), including tables and graphs (ct4), on a standard template prepared by the teacher (ct6).
INNOVATION MANAGEMENT	ING-IND/35	6	The course contributes to defining the relevant professionalism of the roles of RM2 (Innovation Manager), and helps to train the RM1 figure (designer/manager of advanced manufacturing systems), thanks to the discussion - with real cases and examples from the literature - of the possibilities of applying I4.0 technologies for the innovation of products, services and business models. With regard to the RM3 role (service manager), ideas are provided for innovation towards digital services (smart services). The RM4 role (project manager) is also completed by covering the principles of Agile Project Management and providing the fundamentals for portfolio management of different innovation projects. For roles

			RM5 and RM6, knowledge is provided to enable these figures to participate actively in innovation projects of production systems (RM5) and asset management systems (RM6), acting as catalysts of these processes not only in the choice of new technologies, but also in the analysis phase and subsequent adoption and management of change. In particular, in the needs analysis phase, following the principles of Design Thinking, students are asked to work in teams (ct2), collaborating in the development of survey protocols, in the conduction of data collection campaigns (through interviews, surveys, observations), and in the processing and interpretation of collected data, applying descriptive statistics (cc6) and visual statistics (ct4), such as empathy maps and personas diagrams, useful to circumscribe the domain of the problem object of innovation (cc1). Students must then present both written (ct1) and oral (ct3) results to the teacher. Students then have to devise innovative digital solutions that are both functional for satisfying the identified needs (ct5) and sustainable from an economic, social, environmental, technical feasibility and market attractiveness point of view. Particular attention is given to understanding (cc5) the impact and role of I4.0 technologies for product innovation (e.g. IoT for smart connected products), process innovation (e.g. Cognitive Computing for a customer care service) and business model innovation (e.g. a platform that enables matching between supply and demand to provide Manufacturing as a Service). In the design phase, tools are used to stimulate creative generation and brain storming (e.g. SCAMPER, Six Thinking Hat), through which students are asked to train their problem solving, logical thinking (ct6), creative and collaborative intelligence (cc7) skills. Working on the development of a prototype, they have to assess not only the technical but also the economic, social, ethical and environmental risks and implications of their innovation proposals (cc9). Often, the prototype consists of apps, web apps, dashboards (ct8) and other digital data presentation solutions (ct4). Students, following the structuring of composite innovation processes, will also have to consider the constraints and limitations induced by lack of information, and choices under uncertainty (cc8).
SERVICE DESIGN AND MANAGEMENT	ING-IND/35	9	The course introduces the economics of services and provides the elements to understand the peculiarities of service process. The course content is transversal and relevant to many of the professional figures that the management engineering course aims to train. The course aims to provide the necessary elements to undertake the role of service manager (RM3) both in pure service companies and in manufacturing companies offering integrated product-service systems. In addition, the course provides the necessary elements

			for an adequate understanding and management of the servitisation process. With regard to the figure of the operations and supply chain manager (RM5), the course will illustrate how the methods and models for the management of production and logistics systems must be declined in the presence of services in order to manage the variability and heterogeneity that characterises these processes. In relation to the figure of the designer and manager of traditional and advanced production systems (RM1), the limits and opportunities linked to the automation of services will be discussed. Finally, with regard to the figure of the Innovation Manager (RM2), useful tools will be provided for the innovation of service processes and integrated product-service design. Therefore, starting from the knowledge of technologies and industrial resources for production (machines and plants), and the principles of economics and business organisation, the similarities and specificities of services will be understood (cc3). The ability to apply this knowledge to the formulation and understanding of industrial engineering problems involving service processes (ca2) will be developed, fully understanding the stochasticity and heterogeneity arising also from human and intangible factors (ca5, ca7). The course, in fact, also aims to develop the ability to manage one's own time and meet deadlines (ct7), possibly interacting with members of a working group (ct2), in tackling real or simulated problems (ct5, ct10) of dimensioning service delivery systems, making use of appropriate quantitative methodologies and to present in written and/or oral form, in English and using appropriate technical jargon, the results of one's own work (ct1, ct3, ct4, ct6, ct11).

Courses which are mandatory in "International" curriculum			
Double degree base on the agreement with HSLU - Lucerne			
Il dettaglio delle attività formative selezionabili, degli obiettivi formativi e dei relativi crediti acquisibili sono resi disponibili ogni anno sui siti Universitaly e del corso di studio, in occasione della pubblicazione del bando per la partecipazione al programma.			
Context modules	Characterizing	3 each	Up to 18 CFU (ECTS)
Technical scientific specialization	Characterizing	3 each	
Professional specialization	Characterizing	12 o 18	At least 12 CFU (ECTS)
Fundamental theoretical principles	Integrative	3 each	Can be used as elective courses
Suggested elective courses			
Course title	SSD	CFU	Learning objectives
INDUSTRIAL SAFETY	ING-IND/17	6	The course aims to provide in-depth knowledge of the accident prevention regulations in force in Italy and of European Community derivation. These issues are the subject of specific seminars (by a researcher in the labor law area) abaout the sources of labor law and occupational health and safety, in particular focused on community directives and the Legislative Decree 81/2008. The foundation of the right to safety is studied, the corporate organization of prevention and the roles of line (employer, manager and safety responsible), staff (head of the prevention and protection service and the nominated phisician), their functions, the responsibility delegation mechanisms, the health surveillance. The participation of workers and their representatives, obligations, rights, training and information requirements and the disciplinary sanctions are studied. Such knowledge must lead to an understanding of the roles of the various subjects in the prevention for occupational health and safety (cc9, not technical implications, and in particular ethical, legal, and social implications). In the technical area we start from the knowledge of the concept of risk, ontologically dealt with by studying the ISO 31000 standard on risk management, and then reducing it, as a guiding tool, to the requirements of the laws, such as risk assessment and its documentation (cc4, RAMS principles and risk assessment; cc8, applicable techniques and methods and their limitations). In detail, focusing on the main risk factors that can be dealt with more appropriately by engineering skills,i.e. leaving out the aspects closest to the hygienic, medical and physiological area, as well as toxicological chemistry and focusing on ergonomic aspects and on machinery and plant equipment (cc3, production technologies and tools), in addition to the knowledge of the related regulation. If the regulation is "blank", the technical standards (UNI-EN-ISO-CEI-IEC-

			ASHRAE-ANSI etc.) study is addressed, in order to interpretate the technical requirements. The knowledge of the requirements of the law is linked to the knowledge (partly already studied and partly developed ex novo in this course) on the basic technical-scientific elements of the risk factors (cc7, multidisciplinary engineering; ct7, self-directed learning ability). This knowledge develops the ability to understand the risk factors present in a work environment, the causes that produce them, the consequences they can cause, the possible methods for mitigating the related risks in view of legislative compliance and continuous improvement of health and safety at work. Finally, the ability to apply knowledge and understanding is put to the test and further developed in the final part of the course, consisting of the presentation of case studies of accidents at work where the discussion is stimulated on the technical and legal elements learned that find application in concrete cases (ca2, solving engineering problems by identifying the technical, legal, social and economic constraints) and in the motivated choices of appropriate tools and methods (ca4) in a multidisciplinary context (ca7) with a critical evaluation of the available data (ct5, ct10). (ct5, ct10).
PRODUCT AND ASSET LIFECYCLE MANAGEMENT	ING_IND/17	6	The course aims to define the necessary elements of the figure RM1 (Designer and manager of traditional and advanced production systems), as well as improving the competences of the figure RM4 (Project Manager), RM3 (Service Manager) and RM2 (Innovation Manager). The acronym PLM enables a holistic lifecycle-oriented way of thinking through a set of principles, methods and tools supporting a more effective and efficient management of the life cycle stages of industrial products, from their design, to production, distribution, usage until disposal. In its comprehensive meaning, PLM is a business approach based on collaboration and integration of people, processes and technologies, which aims to support the development of more innovative, reliable and sustainable solutions (products and services) in a shorter time. From a managerial perspective PLM encompass a strategic management point of view where the product is the enterprise value creator; the application of a collaborative model and the adoption of a number of IT solutions for establishing an access-safe product information management environment. The aim of the PLM course is to introduce students to the concepts and elements of PLM and lean product and process development, giving also the basics to run the introduction of PLM vin the industrial practice, approach problems and process improvement via lean thinking, with the ultimate purpose to grow a life cycle thinking attitude into the students. From a transversal skills point of view, it will include group work aimed at creating design documents also with the aid of

			multimedia tools (ct1, ct2, ct3, ct4). These activities will be aimed at developing the capacity of independent judgment, analysis of international regulations and synthesis skills (ct5, ct7, ct8, ct11).
DATA DRIVEN NEW PRODUCT AND SERVICE DEVELOPMENT	ING-IND/35	6	In this course, students will learn how to design new products and services using data-driven approaches. Students will learn how to collect and analyze market and customer data, use this data to generate product ideas, and test these ideas to determine their technical and market feasibility. During the course, students will gain a thorough understanding of the principles of data-driven product/service development. They will understand the definition and technologies of Industry 4.0 and 5.0, as well as the role of data-driven organizations in contemporary society. They will learn the process of designing and developing data-driven products and services, including organizational and system design (ca4). They will be able to conduct comprehensive customer and market research (ct6) to identify market opportunities and customer needs using analytical methods and use data to generate innovative ideas for new products/services (ca7). They will learn how to use data-driven approaches to develop a constructive, productive, and economic/financial feasibility study and to generate, select, and test product concepts (ca5, ca6). Finally, they will be introduced to and made to use the data-driven business model canvas as a new data-centric framework, preparatory to understanding how data can be used to facilitate organizational change, identify areas for improvement, test new markets, and measure impact (ca8). Students will learn how to develop and test prototypes to validate their ideas and use experimentation to refine and optimize them. Finally, students will develop a data-driven go-to-market strategy, ensuring that their products/services can be successfully launched and meet customer needs (cc7, cc8, cc9, cc10). The course also has a focus on several soft skills: analytical thinking (ca3), teamwork (ct2), time management (ct7), and communicating the results of their work in written form (ct1), graphics (ct4) and through presentations (ct8).
INDUSTRIAL AUTOMATION TECHNOLOGIES	ING-INF/04	6	The objective of the course is to educate the student on the problems, methodological solutions and technologies that are commonly used in industrial production automation. Objectives in detail: - knowledge of the main architectures and reference models for an Industrial Production System with a focus on the context of Industry 4.0 (ca4) - knowledge of the most commonly used technologies and tools for the implementation of fully automated production processes by means of industrial control systems (cc5, cc8)

			- knowledge of the main reference standards for control systems and communication networks in the industrial environment (ca4) - knowledge of the main issues in the design of a Production Cell treated as an integrated set of fully automated production processes (cc8, ca4, ca5) - ability to identify optimal solutions regarding the regulation of individual production phases and their supervised coordination using data acquisition and processing systems (cc8, ca5, ca7) - ability to recognize the constituent elements of a system for Basic Control and evaluate their correct configuration with respect to both the control objectives and the nature of the physical processes (ct5, ct10) - knowing how to calibrate a PID controller and how to analytically design a linear controller (ct5) - recognize the components of a PLC controller and evaluate its proper configuration with respect to both the desired performance and the context of the devices with which it is interfaced (ct5, ct10) - knowing how to program a PLC controller using standard languages (ct5)
DESIGN OF ICT SYSTEMS FOR BUSINESS MANAGEMENT AND PRODUCTION	ING-INF/03	6	The course aims to provide students with the necessary tools for both the design and evaluation of performance, efficiency, and security of ICT systems in industrial applications, through theoretical and practical lessons. Students will therefore be able to understand the ICT world for industry and assess its added value for companies. The course is aimed at integrating theoretical concepts with the design of practical applications in order to create an ICT system for industrial applications, encouraging students to further explore the topic. The general objective of the course is to provide the necessary skills for a Designer and Manager of traditional and advanced production systems, with a focus on Industry 4.0 (RM1), and an Innovation Manager (RM2). Specifically, the course will provide the basics knowledge of the most innovative technological tools necessary to transmit, collect, and process data extracted from industrial production processes, as well as the knowledge necessary for the design, evaluation of performance, efficiency, and safety of ICT systems in industrial applications (cc5, ct1, ct3, ct4). The student will be able to conduct design analyses for the realization of an efficient and secure communication system using new generation technologies, or for the design of the architecture of a data collection system, deepening the concepts of efficiency and reliability (cc5, cc6). The ability to evaluate and interpret the performance of complex ICT systems critically (ca1, ca4) and the ability to identify the best design choices aimed at improving performance (ca7) will be developed.