MASTER'S DEGREE IN
MECHANICAL ENGINEERING

UNIVERSITA' DEGLI STUDI DELL'AQUILA

Ottobre 2022

# MECHANICAL ENGINEERING

## Master's level (Second cycle) Degree

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|---|---|
| **Title conferred** | Master's level Degree in Mechanical Engineering |
| **Years** | 2 |
| **Credits** | 120 CFU |
| **Language(s) of instruction/examination** | ITALIAN, ENGLISH |
| **Course President** | Prof. Eng. Paolo Di Stefano |
| **Web site** | http://www.ing.univaq.it/ingegneria-meccanica |
| **E-mail** | ing.meccanica@univaq.it |

# MASTER'S DEGREE IN MECHANICAL ENGINEERING

UNIVERSITA' DEGLI STUDI DELL'AQUILA

Ottobre 2022

## Course description

The Master's level (Second cycle) Degree course in Mechanical Engineering aims to provide high-level university knowledge, and skills suitable for managing activities connected with the design of complex products and systems, and with the organization of processes in a large technical-scientific sector, where innovation and research are strategic factors. The course allows to enrich the preparatory engineering knowledge required for admission, with a broad-spectrum and high-level engineering knowledge, with particular reference to the mechanical engineering field. This type of preparation provides the graduate with the tools to solve engineering problems, to design components, machines, energy systems, technologies, mechanical and biomedical structures and systems, to manage industrial production activities and related processes and plants. Furthermore, the acquired knowledge allows graduates to adapt to competitive and dynamic scenarios in which methods, techniques, tools, and technologies evolve continuously.
The educational curriculum for achieving the Master's Degree in Mechanical Engineering includes training activities distributed in a balanced way between courses, aimed at completing the specific preparation, characterizing mechanical engineering, with those of related cultural areas.
The Master's Degree course in Mechanical Engineering offers the possibility of choosing among five different curricula where, with different weights, the issues of energy management and conversion, product design and development in the industrial and biomedical sector, vehicles and automation are dealt with:

- **Biomedical engineering**
- **Energy**
- **Mechatronics**
- **Design**
- **Vehicles**

At the end of the educational path the student will have acquired:

- in-depth knowledge and a clear understanding of the methodological and design bases of mechanical engineering;
- knowledge and understanding of the most rigorous methodologies for the advanced design of components, machines, energy systems, technologies, structures and mechanical systems, as well as for the design and management of complex industrial production activities and related processes and plants;
- critical knowledge of the latest developments of modern technologies in the fields of mechanical design, energy, biomedical engineering, automation, integration of mechanical systems with electronic and information systems, and industrial production.

The training activity is divided into teaching modules with classroom lessons (and, if necessary, remote learning lessons), laboratory exercises and individual study. The relative credits are obtained by passing the exams. The final exam, of an experimental, modelling or design nature, is an integral part of the preparation and often involves training stages in national and foreign institutions, companies, and universities.

## Admission requirements

Students who intend to enrol in the Master's Degree course in Mechanical Engineering must be in possession of a three-year university degree or diploma, or another qualification obtained abroad, recognized as suitable. The skills and knowledge the student has acquired in the previous educational path, are curricular requirements, expressed through the acquisition of at least 120 CFU, referring to specific academic disciplines. In particular, the necessary curricular requirements are the following:

a) A minimum number of 48 CFU for the academic disciplines indicated for the "basic" training activities of the First Cycle degree pertaining to class L9 (INF/01 – Informatics, ING-INF/05 - Information processing systems, MAT/02 – Algebra, MAT/03 – Geometry, MAT/05 - Mathematical analysis, MAT/06 - Probability and statistics, MAT/07 - Mathematical physics, MAT/08 - Numerical analysis, MAT/09 - Operational research, SECS-S/02 - Statistics for experimental and technological research, CHIM/03 - General and inorganic chemistry, CHIM/07 - Chemical foundations of technologies, FIS/01 - Experimental physics, FIS/03 - Physics of matter), of which at least:
   - 12 CFU for the academic discipline MAT/05 (Mathematical analysis)
   - 6 CFU for the academic discipline MAT/03 (Geometry)
   - 12 CFU for the academic discipline FIS/01 (Experimental physics)
   - 6 CFU for the academic discipline CHIM/07 (Chemical foundations of technologies) e/o CHIM/03 (General and inorganic chemistry)

b) A minimum number of 72 CFU for the academic disciplines indicated for the training activities "characterizing" of the First Cycle degree pertaining to class L9, of which at least:
   - 48 CFU in the field of Mechanical Engineering, including at least:
     - 6 CFU for the academic discipline ING-IND/08 (Fluid machinery) e/o ING-IND/09 (Energy systems and power generation)
     - 6 CFU for the academic discipline ING-IND/10 (Thermal engineering and industrial energy systems)
     - 6 CFU for the academic discipline ING-IND/13 (Applied mechanics)
     - 6 CFU for the academic discipline ING-IND/14 (Mechanical design and machine construction)
     - 6 CFU for the academic discipline ING-IND/15 (Design methods of industrial engineering)
     - 6 CFU for the academic discipline ING-IND/16 (Manufacturing technology and systems)
   - 6 CFU in the field of Electrical and/or Electronic Engineering
   - 6 CFU in the field of Materials Engineering

c) Level of knowledge of the English language not lower than B1, with reference to the "Common European Framework of Reference for Languages".

The "Consiglio di Area Didattica" (CAD) may also admit to the Course students whose curriculum does not fully comply with the constraints relating to the articulation of the credits described above, if, based on evaluations of equivalence of the recognized educational contents and eventual verification of the actual knowledge possessed, it is possible to establish the adequacy of the curricular requisites. For these students, the CAD will provide additional information about the definition of study plans.

Additional indications regarding the definition of study plans will also be provided to students who, in the previously followed educational course, have already taken the exams required for the Master's Degree Course in Mechanical Engineering.
The adequacy of the individual preparation is assessed through an interview with a commission nominated by the CAD. Candidates who have achieved a First Cycle Degree with the following results are exempted from the interview:

- duration of the educational course less than or equal to 5 years and final grade of at least 80/110 (or corresponding assessment).
- duration of the educational course over 5 years and final grade of at least 90/110 (or corresponding assessment).

Verification of the admission requirements for continuity candidates (in possession of a First Cycle Degree in Mechanical Engineering or Industrial Engineering, obtained at the University of L'Aquila) is assessed by the Student Secretariat, which can directly proceed with registration. The admission requests of candidates who do not meet the admission requirements are subjected to evaluation by the CAD (or a commission delegated by it), which expresses the final opinion based on the previous career.
The admission of graduates from other universities is always subjected to the evaluation of the CAD (or a commission delegated by it), which admits on the basis of the previous career and the adequacy of personal preparation, verified, possibly, by interview.

## Tutors of the Master's Degree course

Prof. Michele Gabrio Ernesto Antonelli, email: michelegabrioernesto.antonelli@univaq.it
Prof. Jacopo Brunetti, email: jacopo.brunetti@univaq.it
Prof. Davide Di Battista, email: davide.dibattista@univaq.it
Prof. Edoardo Mancini, email: edoardo.mancini@univaq.it
Prof. Emanuela Natale, email: emanuela.natale@univaq.it

## Responsible for the quality of the Master's Degree course

Prof. Luca Di Angelo

## Other useful information

Presentation video of the Master's Degree course in Mechanical Engineering

Double degree in Mechanical Engineering with the Shibaura Institute of Technology (Tokyo)

Living in L'Aquila

How to reach us

Web site

Tuition

DIIIE
Dipartimento di Ingegneria Industriale e dell'Informazione e di Economia

**Master's Degree in Mechanical Engineering**
Piazzale Ernesto Pontieri, Monteluco di Roio, 67100 L'Aquila, Italy
Email: ing.meccanica@univaq.it

# CURRICULUM "BIOMEDICAL ENGINEERING"

## Professional profile and professional and career opportunities for graduates

### Function in an employment context

The Master's level Degree course in Mechanical Engineering, educational path in Biomedical Engineering, aims to provide students with engineering skills, resorting to an interdisciplinary approach, which allows them to face the complex problems of Biomedical Engineering, to operate in different technical, commercial and managerial roles, in public and private work contexts.
In particular, the graduate in Mechanical Engineering with a Biomedical curriculum will be able to deal, at various levels, with the design, development, production, marketing, and management of devices, equipment, and systems for diagnosis, therapy, rehabilitation, and mobility aid, maintaining close interdisciplinary communication and collaboration with medical professionals.
Thanks to the interdisciplinary approach, he will be able to perform high responsibility functions and tasks, and to coordinate activities of technical/engineering content in different industrial contexts, and public and private structures in the biomedical field.

### Careers opportunities

The job market in the field of Biomedical Engineering is growing rapidly, thanks to continuous discoveries in the medical field, new technological frontiers, and the increased needs of modern society in terms of health care and improvement of living conditions.
The career opportunities for a graduate in Mechanical Engineering, educational path in Biomedical Engineering, are, in the industrial sector, in the field of research, design, production and marketing of devices and systems for:

- Diagnosis and monitoring: imaging for diagnostic, biomedical measuring instruments, telemedicine, ...
- Therapy and rehabilitation: rehabilitation systems (active or passive machines for the execution of movements), electro-stimulation machines, infusion systems, ...
- Reintegration or support of deficient functions: implantable devices (prostheses, artificial organs), functional support systems for people with disabilities or for bionic use (passive or active systems, robotic systems), pulmonary ventilation, ...
- Aid to surgery: instruments for minimally invasive surgery, robots for surgery, anaesthesia machines, ...

He will also be able to operate in:

- hospitals and specialized clinical laboratories, to ensure a safe, appropriate and economical use of biomedical technology, and for the management of biomedical data;
- biomedical engineering services in public and private healthcare facilities, in the sector of sport, physical exercise and entertainment;
- service companies for the marketing and management of biomedical equipment and systems;
- public and private administrations and institutions in the healthcare sector and biomedical research.

### Specific educational objectives and description of the educational path

The course in Biomedical Engineering intends to provide the mechanical engineer with a transversal preparation and competence that allows him to face the most complex problems of the design, development

and management of biomedical devices and systems, and to contribute to scientific and technological advancement of the sector. The interdisciplinary nature of the knowledge of a biomedical engineer is essential so that he can find technical solutions, typical of engineering, to medical problems.
Graduates in Biomedical Engineering will be predisposed to innovation, and will be able to update their knowledge and skills in the biomedical field, according to the evolution of industrial technologies on the one hand, and medical science on the other.
In the course of Biomedical Engineering, in addition to the typical teachings of Mechanical Engineering (Machine design, Control systems, Computer aided engineering, Mechanism design), which provide engineering tools for modelling, design and control of systems, teachings more specifically oriented towards the topics of the biomedical area are offered, such as:

- Mechatronics and design of biomedical devices;
- Thermal and mechanical measurements for Biomedical Engineering;
- Robotics for Biomedical Engineering;
- Mechanical behaviour and rapid prototyping of biomedical devices;
- Modelling techniques for Biomedical Engineering;
- Bio thermo fluid dynamics;
- Management of healthcare systems and medical diagnostic instrumentation.

The educational course is completed with the activities chosen by the student, training stages in companies or laboratories, and the final exam.

**Knowledge and understanding**

The Master's level Degree course in Mechanical Engineering, educational path in Biomedical Engineering, provides advanced knowledge, characterized by a high degree of interdisciplinarity between the areas of mechanics, materials science, industrial technologies, automation, and biology.
In particular, the educational path in Biomedical Engineering provides the in-depth knowledge and the ability to understand, typical of the Mechanical Engineer background, with reference, in particular, to modelling techniques, principles of thermo-fluid dynamics, advanced design tools and methods, control techniques. This knowledge, however, is mainly oriented to the analysis, modelling, design and development of devices, equipment and systems for specific biomedical applications (diagnosis and monitoring, therapy and rehabilitation, reintegration or support of functions, aid in surgical operations), which require additional knowledge regarding the specific characteristics of the living systems.
Furthermore, the Biomedical Engineering path educates in inter-sectoral dialogue, and provides the knowledge and understanding of the common language that makes this dialogue possible.

**Ability to apply knowledge and understanding**

The acquisition of knowledge during the path of Biomedical Engineering, and the direct experience with practical examples of application of this knowledge, through exercises, laboratory activities, training stages and final test, allow the student to acquire specific skills, that is the ability to operate in the biomedical sector concretely.
At the end of the educational path, the graduate will therefore have the ability to apply the knowledge and understanding acquired for:

- identifying, developing and using the most appropriate mathematical models to solve specific problems in the field of analysis, design and development of complex biomedical systems;
- managing a project in all its phases, starting from the identification of functional requirements, up to the conceptual and concrete development;

- applying methods and tools of mechanics and mechatronics in the design of biomedical devices and systems;
- developing, evaluating and managing innovative products and materials, with particular reference to "prototyping and additive manufacturing";
- applying the knowledge of the operating principles of biomedical instrumentation for their characterization, certification, testing, commissioning, maintenance, and for the development of use and data processing procedures;
- carrying out experiments and analysing and interpreting the results;
- interacting with health professionals in biomedical applications.

Teachings and educational path **"BIOMEDICAL ENGINEERING"**

| 1st YEAR | | | 2nd YEAR | | |
|---|---|---|---|---|---|
| **Teaching** | **CFU** | **Sem.** | **Teaching** | **CFU** | **Sem.** |
| Control systems | 6 | I | Robotics for biomedical engineering; | 9 | I |
| Computer-aided engineering in Biomedical applications | 9 | I | "Mechanical behaviour and rapid prototyping of biomedical devices", integrated course of:<br>- DG0196 Mechanical behaviour of biomedical materials and devices<br>- DG0182 Rapid prototyping and additive manufacturing | 12 | I |
| Mechanism design | 6 | I | Modelling techniques for biomedical engineering | 6 | II |
| One course chosen from:<br>- Electrical motors and drives<br>- Management of healthcare systems and medical diagnostic instrumentation | 6 | I | "Bio thermo fluid dynamics", integrated course of:<br>- DG0191 Bio thermodynamics<br>- DG0192 Bio fluid dynamics | 12 | II |
| "Mechatronics and design of biomedical devices", integrated course of:<br>- DG0068 Mechatronics (EN)<br>- DG0188 Design of biomedical devices | 12 | II | Further activities | 3 | I/II |
| Machine design | 9 | II | Choice of the student | 9 | I/II |
| Thermal and mechanical measurements for biomedical engineering | 6 | II | Final exam | 12 | |
| English language B2 | 3 | | | | |
| | | | | | |

*(EN): courses in the English language*

# CURRICULUM "ENERGY"

## Professional profile, job and professional opportunities

The mechanical engineer with a master degree in Energy course will be able to operate in multiple companies involved in the production, management, and conversion of energy in the industrial sector, in plant design, maintenance, testing, and operation companies, in the Automotive sector, and public and private research institutions. The actual sensitive issue of energy transition and, thus, the gradual transition from fossil to renewable energy, requires a wide-ranging professional with transversal competences in the field of mechanical, energetic, and plant engineering. In this way, the energy mechanical engineer is an undisputed protagonist of the so-called "Green Economy", having an important role of responsibility and coordination of intense technical/engineering activities in the social and economic panorama.
The main job opportunities for an Energy master Mechanical Engineer can be resumed as follows:

- Energy conversion companies
- Design of fluid machines
- Installation, testing maintenance, and management of machines
- Thermoelectric, hydroelectric, and geothermal sectors
- Extractive and petroleum industries
- Renewable energy plants design
- Energy management
- Public and private technical offices for energy and environment
- Production, management, and maintenance of cold chain companies
- Plant companies
- Automotive and transport sector
- Thermo-technical buildings design
- Companies in the energy and environment business
- Industrial and residential energy efficiency
- Energetic services in manufacturer and production companies
- Plant upgrading in the energetic transition field

## Specific educational objectives and description of the training course

The training course in "Energy" gives the mechanical engineer specialized training in the design and management of energetic transformations disciplines: air conditioning and thermo-hygrometric comfort; thermodynamic and fluid dynamics of complex systems (Internal combustion engines, turbomachines, power plants, refrigeration systems); interaction with the environment; tuning and control systems for energy plants; energy efficiency of industrial sector for an environmental impact reduction; energy primary sources management and energy technologies for sustainability.
The education provides the student to apply methods, technics, and tools for energetic issues. The training course is organized as follows: in the first year, transversal subjects, such as control systems, computational fluid dynamics, computer aided engineering, measures, take place, while in the second year, advanced energetic systems, machines dynamic and control, building energetic characterization, internal combustion engines, design of turbomachines, technologies for energy transition, renewable energy sources utilization are presented.

The training course is completed by choosing other activities, such as laboratory and internships. Every lessons and exercises are given in the classroom, while laboratory activities take place in the facilities of DIIIE.

**Knowledge and understanding**

The student learns heat transfer, thermodynamic and fluid-dynamic processes for machines, and energy conversion. Power transmission, especially for gas and vapor power plants, fluid machines, and internal combustion engines are explained. Actual building energy characterization for high-tech regulation systems. Understanding of combustion processes of fossil and sustainable fuels. Knowledge of complex system regulation and control (internal combustion engines, propulsion systems, fossil, and renewable power plants) and its environmental impact. Awareness of modern energetic technologies for sustainability and energy transition. Knowledge of energy and environmental markets.

**Ability to apply knowledge and understanding**

Ability to apply methods and theoretical basis of the thermal and energetic analysis of machines and real complex systems. Ability to identify and use the most appropriate mathematical model to solve specific problems in the field of energetic processes. Ability to recognize the most interesting energetic vectors for industries, based on environmental, economical, and social criteria, regarding combined energy production (Cogeneration, trigeneration). Ability to choose principal components of energy conversion systems to satisfy main technical and economical requests. Ability to identify the main component of energy plants' thermal dynamic. Ability to solve problems related to machines and complex systems design. Ability to evaluate alternative solutions in order to increase energy efficiency and reduce environmental impact in the industrial sector, but also residential and transportation sector. Ability to make economical evaluations to support the opportunity of energy management.

These abilities are acquired through classroom activities, that stimulate interaction with other classmates, and experimental experiences in the laboratory. Finally, exercises, exams, and internships can accurately evaluate students' preparation.

Teachings and educational path **"ENERGY"**

| 1st YEAR | | | 2nd YEAR | | |
|---|---|---|---|---|---|
| **Teaching** | **CFU** | **Sem.** | **Teaching** | **CFU** | **Sem.** |
| Control systems | 6 | I | Heat Transfer II and Engineering Thermodynamics II | 9 | I |
| Computational fluid dynamics | 6 | I | Sustainable Energy technologies | 9 | I |
| Computer aided engineering | 9 | I | Mechanical vibrations | 9 | I |
| Thermal and mechanical measurements and testing | 9 | II | Turbomachines and Internal Combustion Engines | 9 | II |
| Machine design | 9 | II | Dynamics and control of machines | 9 | II |
| Management of energy conversion systems | 9 | II | Further activities | 3 | I/II |
| Choice of the student | 9 | | Final exam | 12 | |
| English language B2 | 3 | | | | |

*(EN): courses in the English language*

# CURRICULUM "MECHATRONICS"

## Professional profile and professional and career opportunities for graduates

### Function in an employment context

The graduate with a master's degree in mechanical engineering, educational path in Mechatronics, will be a professional figure able to integrate mechanical, electrical, electronic, and IT systems. This professional figure, whose demand has been growing a lot in recent years both nationally and internationally, will be placed within the new concept of industry, the so-called Industry 4.0, where multidisciplinary skills are required to grow and strengthen various industrial sectors, including industrial automation, robotics, and smart technologies. In this context, the function of the engineer with this training will be to introduce the mechatronic approach to design, based on the integration of different technologies, for multiple purposes: optimization of the performance of machines and automatic lines for increasing production capacity, reduction of waste, data collection at company level with the consequent increase in company competitiveness; management and maintenance of already technologically advanced lines to ensure their high level of performance and efficiency; evolution of existing mechanical systems and development of new technologically advanced products, plants, processes, and systems, equipped with sensors and controlled by electronic and IT devices; design, development, and prototyping of robotic and automatic systems equipped with intelligence; installation and testing of new equipment and instruments. Furthermore, given the growing innovation in the agriculture, autonomous and remote piloted driving sectors, and in the biomedical industry, this figure will be the protagonist of the development of new intelligent construction solutions for the execution of automatic harvesting operations, monitoring of plants, soil treatment and the development of new mobile devices for different applications and new biomedical devices. Indeed, the research and development sector, public or private, are areas in which this figure will work, as well as in consulting firms and the freelance profession.

### Careers opportunities

The skill to integrate mechanics with different technologies creates many employment opportunities for the mechanical engineer trained with mechatronic skills. Therefore, the work areas of this professional figure can be as follows:

- companies that design and build automatic lines and machines;
- companies that design and build complex, highly automated systems;
- companies that design and build integrated systems in various sectors such as mechanics, automotive, robotics, aeronautics, agromechanics, textiles, electronics, and the biomedical industry;
- industrial production companies;
- companies operating in the renewable energy sector;
- systems integration service companies;
- consulting company;
- freelancer.

### Specific educational objectives and description of the educational path

The educational path aims to provide skills in the use of methods and theoretical foundations learned for the analysis of various problems in the field of mechanical engineering, in which knowledge is also required in the fields of electrical, electronic, and automation engineering. Therefore, the educational path provides, deepens and expands the knowledge and skills for the identification and use of the most appropriate mathematical models to solve specific problems in the field of design and development of industrial systems and complex products, even in their mechatronic components; for the management of projects in all their phases starting

from the identification of the functional requirements to the conceptual and concrete development; for designing and developing automatic, mechatronic systems including the equipment of sensors and control devices; for testing automatic devices and systems and to verify their functional performance.
Furthermore, the educational path in Mechatronics is part of an international course for the release of the double degree (Double Degree) with the Shibaura Institute of Technology in Tokyo. The most deserving students will be able to access a path that allows them to achieve, in the two-year study period, the Italian Master's Degree in Mechanical Engineering and the Master of Science in the Field of Mechanical Engineering, whose legal value is recognized in both countries. This path includes a year of studies in L'Aquila and a year in Japan. For this internationalization opportunity, the Mechatronics educational path includes some courses held entirely in English.
The educational path is divided as follows: in the first year, both transversal teachings are dealt with concerning computer aided engineering, machine design, and mechanical measurements, and characterizing courses dedicated and aimed at specific in-depth studies concerning mechatronics, electronics, controls, and electric drives and motors; similarly, in the second year, transversal teachings are addressed, concerning the mechanical vibrations and the product design and development, and characterizing teachings concerning mechanical automation and the dynamics and control of propulsion systems.
The educational path is completed with courses chosen by the student, with other activities to be carried out in the Laboratories of the Department of Industrial and Information Engineering and Economics or in the form of internships to be carried out in Companies or other Research Institutions, and with the preparation and the discussion of the thesis work, to be carried out in the same way as for the other activities.

**Knowledge and understanding**
At the end of the educational path in Mechatronics, the new engineer will acquire knowledge relating to the analysis, conceptual development, and functional and concrete design of assemblies and complex mechanical systems, with particular reference to robotic devices, automatic systems, and mechatronics in general; knowledge of the main technologies used for the automation of mechanical systems and the automatic control of various types of actuation devices (mechanical, electrical, pneumatic, hydraulic); knowledge and understanding of the characteristics of mechatronic and robotic systems and the techniques of analysis and synthesis of the mechanisms for automatic machines; understanding of the problems relating to product development processes and development of an aptitude for problem-solving. For those who follow the international path, the knowledge of cultural and socio-economic realities significantly different from the Italian one, and the ability to work and communicate in international work groups are added.

**Ability to apply knowledge and understanding**
At the end of the educational path in Mechatronics, the new engineer will have: the skill to conceive and design mechatronic products and systems and the know-how to identify the main and interface components; the skill to apply traditional and advanced design techniques, using numerical calculation codes, for modeling, simulation and functional validation of mechatronic products and systems; the skill to develop control algorithms and implement them through microprocessor controllers; the skill to integrate mechanical systems with sensors and human-machine interface and control systems; the skill to program robotic systems and, more generally, systems for industrial automation.
These skills are acquired through classroom activities and exercises, in which the ability to interact in groups with other students is also stimulated, and through experimental laboratory activities. The acquisition is verified through exercises, exams, training internships, and the final exam.

# MASTER'S DEGREE IN MECHANICAL ENGINEERING

UNIVERSITA' DEGLI STUDI DELL'AQUILA

Ottobre 2022

Teachings and educational path **"MECHATRONICS"**

| 1st YEAR | | | 2nd YEAR | | |
|---|---|---|---|---|---|
| **Teaching** | **CFU** | **Sem.** | **Teaching** | **CFU** | **Sem.** |
| Control Systems | 9 | I | Mechanical automation and mechatronics | 9 | I |
| Computer aided engineering | 6 | I | Mechanical vibrations | 9 | I |
| Electrical drives and motors | 9 | I | Product design and development | 9 | II |
| Mechatronics (EN) | 9 | II | Propulsion Systems Dynamics and Control (EN) | 9 | I |
| Machine Design | 9 | II | Choice of the student | 9 | |
| Electronic Systems for Mechatronics (EN) | 6 | II | Further activities | 3 | |
| Thermal and mechanical measurements and testing | 9 | II | Final exam | 12 | |
| English Language B2 | 3 | | | | |

*(EN): courses in the English language*

# CURRICULUM "DESIGN"

## Professional profile and employment and professional opportunities for graduates

The professional figure of the mechanical engineer requires the knowledge, skills and technical-scientific competencies necessary to understand, describe, formulate and solve complex problems that typically arise in an industrial context. It must be able to interact with professional figures from different cultural backgrounds, lead teamwork and operate within a company organisation with autonomy and flexibility in compliance with professional ethics. The graduate' in mechanical engineering with a master's degree in Design will be able to design and verify both simple and complex mechanical systems and solve, in an innovative way, complex and interdisciplinary problems in which technical, functional, and economic requirements interact.

*Careers opportunities*

Students in mechanical engineering master machine design programs generally wish to enter the industry as practising professionals or pursue doctoral studies. A recent survey indicates that newly graduated with mechanical engineering in machine design degrees are working as:

- Product design engineers in automotive, aeronautics and aerospace industries;
- Mechanical engineers
- Analysts
- Consultants
- Researchers
- Developers
- Freelance professional

**Specific educational objectives and description of the educational path**

The Master's level Degree course in Mechanical Engineering, the educational curriculum in Design, aims to provide students with high expertise and skills capable of performing and managing complex activities related to the design and development of scientific and technological innovation and the promotion of research in a broad scientific and technical field.

The machine design curriculum is designed to provide to the graduate students with the theoretical basis and the ability to use the methods necessary for the analysis of various problems that may arise in the field of mechanical engineering. In this perspective, improve the knowledge and skills to identify and use the most appropriate mathematical and/or numerical models to tackle specific problems in the field of design and development of industrial systems and complex products. In addition, the ability to manage a project in all its phases from the identification of functional requirements to conceptual development, prototyping and then realisation is provided. These objectives are pursued by means of a training activity divided into classroom and laboratory lectures, class and individual exercises, and the latter on projects specifically assigned by the teachers.

The design curriculum is designed as the following: in the first year, both transversal teachings are dealt with concerning computer aided engineering, machine design, and mechanical measurements, and characterizing courses dedicated and aimed at specific in-depth studies concerning the management of technological processes, control systems, and functional mechanical design; similarly, in the second year, transversal teachings are addressed, concerning the mechanical vibrations and the product design and development, and

characterizing teachings concerning mechanical devices and systems for automation, and dynamics and control of machines.

The design curriculum is completed by lectures chosen from the students and other activities made in the Laboratories of the Department of Industrial and Information Engineering and Economics or the form of internships to be carried out in Companies or other Research Institutions. Finally, the student will have to defend his thesis work.

**Knowledge and understanding**
At the end of mechanical engineering master machine design programs, the graduate students will have acquired the knowledge and understanding of the processes involved in product design, process technologies, machines and complex mechanical systems. Moreover, graduates from the programme will be able to tackle advanced design issues, including highly complex ones, and take care of innovation and development of new products and new technological processes also when the data will be supported by little information and with conflicting specifications.
Finally, the acquired skills will enable him to tackle projects of articulated mechanical systems, identifying and applying both the most suitable calculation method, analytical or numerical, and if necessary the experimental verification, all aimed at analysing and dimensioning them.

**Ability to apply knowledge and understanding**
At the end of mechanical engineering master machine design programs, the neo-engineer will have: the ability to be able to use the methods and theoretical bases learnt for the analysis of various problems in the field of mechanical engineering; the ability to identify and use the most appropriate mathematical and numerical models to solve specific problems in the field of machine dynamics and kinematics as well as relating to the integration aspects of the knowledge required for the design of a modern industrial product; the ability to manage a project in all its phases starting from the identification of functional requirements to conceptual and concrete development; the ability to tackle and solve problems concerning the development of even complex products in which transversal engineering skills are required; the ability to create finite element models of mechanical components or simple assemblies and to use the appropriate techniques and tools to tackle complex engineering problems; the ability to verify the structural resistance and assess the reliability of components, assemblies and mechanical systems and industrial products, under normal and severe conditions of use; the ability to solve new design problems, also with little information and with conflicting specifications by taking the most appropriate decisions.

# MASTER'S DEGREE IN MECHANICAL ENGINEERING

UNIVERSITA' DEGLI STUDI DELL'AQUILA

Ottobre 2022

Teachings and educational path **"DESIGN"**

| 1st YEAR | | | 2nd YEAR | | |
|---|---|---|---|---|---|
| **Teaching** | **CFU** | **Sem.** | **Teaching** | **CFU** | **Sem.** |
| Control Systems | 6 | I | Mechanical devices and systems for automation | 9 | I |
| Computer aided engineering | 9 | I | Mechanical vibrations | 9 | I |
| Functional mechanical design | 9 | I | Product design and development | 9 | II |
| One course chosen from:<br>- Computational fluid dynamics<br>- Electrical drives and motors<br>- Electronic Systems for Mechatronics (EN) | <br>6<br>6<br>6 | <br>I<br>I<br>II | Dynamics and control of machines | 9 | II |
| Machine Design | 9 | II | Choice of the student | 9 | |
| Management of technological processes and automotive technologies | 9 | II | Further activities | 3 | |
| Thermal and mechanical measurements and testing | 9 | II | Final exam | 12 | |
| English Language B2 | 3 | | | | |

*(EN): courses in the English language*

DIIIE Dipartimento di Ingegneria Industriale e dell'Informazione e di Economia

**Master's Degree in Mechanical Engineering**
Piazzale Ernesto Pontieri, Monteluco di Roio, 67100 L'Aquila, Italy
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# CURRICULUM "VEHICLES"

## Professional profile, employment and professional opportunities for graduates

### Function in a work context

At the end of the educational path in vehicle engineering, the mechanical engineer will have a specialized preparation that will allow him to face the typical problems associated with the design, production, and management activities of companies involved in the development and production of land vehicles. The industrial transport sector is constantly evolving, fueled in recent years by tightening regulations on polluting emissions. Therefore, continuous development of thermal propulsion solutions is observed together with progressive electrification of vehicles. In addition, the growing interest in driving support functions and autonomous driving systems is leading to the development of vehicles with an increasing number of onboard sensors and increasingly powerful data processing capabilities. Finally, innovations in materials and production technologies, together with the evolution of Industry 4.0, provide designers with new possibilities in developing vehicles and their components. In this context, the mechanical engineer with an educational path in vehicle engineering can solve the complex and interdisciplinary problems that typically arise in such a complex industrial environment, often innovatively. Solid cultural foundations are required to address and solve issues associated with designing and developing mechanical systems, propulsion systems, and technological processes in the vehicular field. Graduates in mechanical engineering with the educational path in vehicle engineering can interact with professional figures of different cultural backgrounds, conduct work groups, and operate autonomously within a complex business organization, respecting professional ethics. The skills developed during the studies allow the graduate: to master mathematics and other basic sciences to interpret and describe the complex and interdisciplinary problems typical of mechanical engineering; master the topics of mechanical engineering of particular interest in the vehicle industry; to be able to devise, plan, design and manage complex and innovative systems; to be able to design experiments of high complexity. These skills can also be expressed in the liberal profession or as employees within manufacturing companies, service companies, or public administration.

### Job opportunities

The professional opportunities for graduates with a master's degree in Mechanical Engineering after a training path in vehicles engineering are expected to be in manufacturing and services companies, public administrations, research institutions, and the liberal profession. The specific competencies acquired in the field of vehicles provide the following preferential professional opportunities:

- companies that design and manufacture vehicles (cars, motorcycles, trucks, buses, agricultural vehicles, earthmoving vehicles, military, and special vehicles, trains);
- companies that produce components for the automotive and transport sectors;
- companies that design and manufacture endothermic engines for transport;
- transport companies (railways, subways, urban transport);
- technical roles in public and local authorities;
- liberal profession for insurance and legal matters;
- research and development in automotive research centers;
- consultancy and training for automotive companies.

**Specific training objectives and description of the educational path**

The Master's Degree in Mechanical Engineering with an educational path in vehicles engineering aims to train technicians with high-level academic skills. Graduates can manage complex design and development activities with scientific and technological innovation and promote research in both the technical and scientific fields.
The course provides students with the advanced skills in vehicle engineering and the professional skills needed to solve complex engineering problems; advanced design of components, thermal engines, technologies, mechanical structures, and systems for the automotive industry; modeling and studying vehicle dynamics and propulsion systems; design of control systems.
In addition, the acquired knowledge must adapt to evolving scenarios of methods, techniques, tools, and technologies. These objectives are achieved through a training activity divided into teaching modules, which include classroom lessons, laboratory exercises, and study or individual exercises.

**Knowledge and understanding**

At the end of the Master's Degree course in Mechanical Engineering with a training path in vehicles engineering, the graduate is able to understand the typical problems of mechanical engineering; knows how to design and dimension mechanical components and systems; knows how to define the architecture of a complex mechanical system aimed at satisfying given technical specifications; is able to evaluate models representing mechanical structures critically and to analyze their dynamic behavior; knows the most modern methods of design using 3D software technologies; is able to control electric motors and drives; masters numerical methods for the solution of the equations that govern the motion of fluids and bodies; knows the main problems arising with the industrialization of engineering products and is able to manage manufacturing processes; knows the basis of automatic controls; masters the analytical and numerical tools for modelling the dynamic behaviour of a vehicle in terms of safety and performance; has a deep understanding of the vehicle dynamics in both stationary and transient condition; knows the main functional models of tires, suspensions, steering, brakes, and transmissions; knows principles of reciprocating internal combustion engines (ICE), with a complete understanding of thermo and fluid dynamic aspects and the most relevant phenomena that affect ICE performance and environmental impact, together with the solutions and technologies aimed at reducing consumption and emissions; understands the issues of the transport sector and sustainable mobility and knows the technologies for vehicle and propulsion system control; knows the operative characteristics of propulsion systems; knows and understands the phenomena occurring in internal combustion engines and unconventional propulsion systems.

**Ability to apply knowledge and understanding**

At the end of the Master's Degree course in Mechanical Engineering with a training path in vehicles engineering, the graduate will be able to: identify and use the most appropriate mathematical models to solve specific problems in the design and development stages of vehicles and components; manage a complex project in all its stages, from the identification of functional requirements to conceptual and executive design; use the appropriate methods and theoretical knowledge for the analysis, modeling and development of complex systems; apply traditional and advanced design techniques, using numerical codes, for modelling, simulating and for the experimental validation; analyse the aerodynamic performance of road vehicles; integrate and control electric motors and drives in applications; design and validate control systems; model and analyse the dynamics of a vehicle in both stationary and transient conditions; use the main functional models of tyres, suspensions, steering, brakes, transmissions; assess the main factors determining the directional behaviour of a vehicle, traction, braking and its safety; associate the characteristics of MCI to their individual components; develop new original and innovative ideas, in a highly competitive and constantly

evolving sector; operate in presence of uncertainties and to work in total autonomy; select the most appropriate propulsion system. The operative skills are tested and improved with the solution of practice cases, addressed as individual activities and working groups. These allow consolidation of the theoretical content provided in the individual courses. In particular, students will carry out project activities to apply the acquired knowledge in applicative scenarios.

Teachings and educational path **"VEHICLES"**

| 1st YEAR | | | 2nd YEAR | | |
|---|---|---|---|---|---|
| **Teaching** | **CFU** | **Sem.** | **Teaching** | **CFU** | **Sem.** |
| Control systems | 6 | I | Thermal engines for automotive | 9 | II |
| Computer aided engineering | 6 | I | Vehicle dynamics | 9 | II |
| Computational fluid dynamics and vehicle aerodynamics | 9 | I | Product design and development | 9 | II |
| Electrical drives and motors | 9 | I | Propulsion systems dynamics and control (EN) | 9 | I |
| Management of technological processes and automotive technologies | 9 | II | Further activities | 3 | I/II |
| Machine design | 9 | II | Choice of the student | 9 | I/II |
| Thermal and mechanical measurements and testing | 9 | II | Final exam | 12 | |
| English language B2 | 3 | | | | |

*(EN): courses in the English language*