

# Internal Double Degree in Mechanical and Materials Engineering and Nanotechnology

## Foreword

In recent years demand for professional figures based on more transversal skills and technical competencies became very evident. These features cannot be offered by a single conventional Master degree programme. Starting from the year 2011 the idea of joint programs was set at Politecnico di Milano and new roadmaps for joint Double Degrees (DD) have been established in order to combine complementary skills and to culturally widen the current degree programs.

The general objective of this approach was to fully exploit synergisms and complementarities among different master degree study plans, to make educational offer more flexible and to better match current dynamics of industrial world.

## Learning objectives

The study plan of the Master degree in Materials Engineering and Nanotechnology is aimed at producing an advanced professional profile for a material expert and designer of processes and components. To that purpose, a deep knowledge of the characteristics and uses of the different classes of materials, as well as of the more advanced processing techniques and of their influence on the final properties of the products is required.

The study plan of the Master degree program can be divided in two parts: 80 credits out of the total amount of 120 credits are compulsory and provide the student with an advanced knowledge of engineering materials and general methods, with special emphasis on structural and functional properties. Additional 20 credits, can be decided by the student among preselected tracks (PSPA) which in fact represent a good opportunity for developing personal attitudes and interests. These thematic tracks are devoted to specific industrial sectors or applications of materials, as well as to fundamental materials studies: Surface Engineering, Polymer Engineering, Nanomaterials and Nanotechnology, Engineering Applications, Micromechanical Engineering. Finally, 20 credits are assigned to the thesis work.

The Master of Science Mechanical Engineer that graduates at Politecnico di Milano is a professional technician, able to design and to develop innovative and advanced mechanical products and processes from different aspects - function, with enhanced structural integrity, energy efficiency, with an appropriate choice of the materials and of the processing methods and production technologies. In addition, the Master of Science Mechanical Engineer is able to design the layout of a production plant and manage it for optimum production rate, to design systems in the field of thermal and mechanical measurements, to design the control systems and the automation technology of complex mechanical systems.

In the first year, high level engineering education is reinforced with an increase in knowledge of advanced analysis methodologies that in the second year are applied to Master of Science modules organized according to thematic tracks and in the Master of Science thesis development. The tracks currently proposed are: Production Systems; Mechatronics and Robotics; Virtual Prototyping; Engines and Turbomachinery; Advanced Materials and Technology; Ground Vehicles; Machine Tools and Manufacturing Systems. 20 credits are assigned to the thesis work.

The Materials-Mechanical Engineer coming from the DD program here described acquires during the three-year course a combination of knowledge featuring a sound background on applied disciplines of engineering, together with wide scientific skills on materials and processes in order to: "know how to design and manage processes, plants and complex systems by exploiting at the highest level modern structural and functional materials".

This new professional figure would be adopted by industrial world with great favour since in many technical fields, not only those concerned with research and innovation, design engineers, production and plant managers are required with expertise combining mechanical engineering and materials science. Figures about employment in recent years, clearly show that in private industry both profiles are highly recognized and it can be reasonably supposed how a professional combining both profiles acquired by the DD programme would be sought and appreciated.

### **The study plan**

A total of 180 credits (or 179, depending on the degree of enrollment) over three years should be gained to obtain the DD in Materials-Mechanical Engineering. Students will therefore need to select courses in excess with respect to the standard Master of Science program (120 credits over two years). The applicants have to enroll in the M.Sc. in Materials Engineering and Nanotechnology or in Mechanical Engineering and then present a – formally – individual study program to extend their career over the third year.

Considering the current study plans of the individual master degree courses and the specific requirements set by the Degree Classes of the Italian Ministry of Education, it is expected that the students coming from one of the two individual study plan would develop a multidisciplinary graduation thesis covering topics typical of both the study programs at the end of the second year and during attendance of the third year. The second degree title will be acquired once further 60 credits (or 59, depending on the first degree registered) will be gained and the first Master degree title is achieved.

The overall DD study plan should not be considered as a new track ad-hoc built for an hybrid professional figure, but rather as a set of accurately tuned tracks aimed at supplying to a Mechanical Engineer all the fundamental knowledge required for an additional master degree in Materials Engineering (MEC-MAT study plan) and to a Materials Engineer those required for an additional master degree in Mechanical Engineering (MAT-MEC study plan). These combined tracks generally adopt pre-existing courses, selected among those offered by the Master degree study plans, in order to supply fundamentals about the second degree.

## Structure of the study plan

The study plans are developed and specifically tuned for Material Engineering students wishing to expand their expertise on Mechanical Engineering (MAT-MEC track) and for Mechanical Engineering students with specific interest in focusing on Materials Engineering and Nanotechnology (MEC-MAT track).

### MAT – MEC track

The proposed track during the first two years matches that of the standard program of Materials Engineering and Nanotechnology Master degree. During the third year, comparing to the standard program for Mechanical Engineering, the courses of APPLIED METALLURGY (6 credits) and CONTROL AND ACTUATING DEVICES FOR MECHANICAL SYSTEMS (9 credits) become not mandatory, so that an overall amount of 32 credits (20 coming from MAT programme + 12 from MEC programme) are available for optional courses. The interdisciplinary thesis work accounting for 20 further credits allows reaching a total of 179 credits required to earn the DD title.

year I – MAT					
Code	SSD	Course Title	Semester	CFU	CFU group
096240	MAT/07	MATHEMATICAL METHODS FOR MATERIALS ENGINEERING	1	5	5
054185	CHIM/07	CHEMISTRY FOR MATERIALS ENGINEERING	1	5	5
054186	ING-IND/22	INSTRUMENTAL METHODS FOR MATERIALS ANALYSIS	1	5	
054187	ING-IND/22	PRINCIPLES OF POLYMER CHEMISTRY	1	5	5
054188	ING-IND/22	PRINCIPI DI CHIMICA DEI POLIMERI	1	5	
054191	ING-IND/14-21	MECHANICAL BEHAVIOUR AND FAILURE OF METALS	1	5+5	10
054335	ING-IND/23	SURFACE ENGINEERING	2	5	10
054336	ING-IND/22	SURFACE TECHNOLOGY	2	5	
054192	ING-IND/23	IMPIANTI E FENOMENI DI TRASPORTO	2	5	
089473	FIS/03	SOLID STATE PHYSICS	2	10	10
085888	FIS/03	FISICA DELLO STATO SOLIDO	2	10	
097485	ING-IND/14	MACHINE DESIGN	2	5	5
		Courses to be chosen from Group ALTRI	1-2		10
		Courses to be chosen from Group DI			
				Total	60

year II - MAT					
Code	SSD	Course Title	Semester	Credits	CFU group
091584	ING-IND/22	ADVANCED MATERIALS	1	5+5	10
052517	ING-IND/22	MECHANICAL BEHAVIOUR AND DURABILITY OF POLYMERS	1	5+5	10
054339	ING-IND/22	CORROSION ENGINEERING OF METALS AND CERAMICS	1	5+5	10
		Courses to be chosen from Group ALTRI	1-2		10
		Interdisciplinary thesis work *		20	20
				Total	60

year III – MEC				
Code	SSD	Course Title	Semester	Credits
8301 7	ING- IND/09	ENERGY SYSTEMS LM	1	7
8586 3	ING- IND/16	ADVANCED MANUFACTURING PROCESSES	1	10
8293 7	ING- IND/14	MACHINE DESIGN 2	2	10
8301 4	ING- IND/13	MECHANICAL SYSTEM DYNAMICS	2	5
8301 5	ING- IND/12	MEASUREMENTS	2	5
8301 6	ING- IND/17	DESIGN AND MANAGEMENT OF PRODUCTION SYSTEMS	2	10
		OPTIONAL COURSES (selected among PSPA tracks found in MEC)		12
		Interdisciplinary thesis work *		
			Total CFU	59

\* The interdisciplinary thesis work is generally carried out starting from the second semester of the second year. The thesis may have one thesis advisor from the Materials and Nanotechnology Engineering Program or two co-advisors, from the Materials and Nanotechnology Engineering and Mechanical Engineering Program. Once the thesis topic has been defined, the student is invited to discuss their choice with the Dual Degree program manager

At the end of the MAT-MEC double degree program, the student will be awarded with two Degrees (in Materials Engineering and Nanotechnology and in Mechanical Engineering). The Master degrees score will be determined on the basis of the weighted average score of exams plus an increment (ranging from -1 and 7 points on 110) for the thesis. The increment will be unique for both the Degrees, while the weighted average score will be determined:

- For the Master Degree in Materials Engineering and Nanotechnology, considering the weighted average score of the courses offered by the Materials Engineering and Nanotechnology program (100CFU) reported in table referring to Year I -MAT and Year II – MAT above.
- For the Master Degree in Mechanical Engineering, considering the weighted average score for the courses offered by the Mechanical Engineering program (59CFU) reported in table referring to Year III – MEC above and the courses plus 097485 - MACHINE DESIGN, 096240 - MATHEMATICAL METHODS FOR MATERIALS ENGINEERING; 054191 - MECHANICAL BEHAVIOUR AND FAILURE OF METALS, 052517- MECHANICAL BEHAVIOUR AND DURABILITY OF POLYMERS, 054339 - CORROSION ENGINEERING OF METALS AND CERAMICS (40 CFU) offered by Materials Engineering and Nanotechnology program.

## MEC – MAT track

The proposed program for students coming from the two-year Mechanical Engineering course follows the idea of recovering the fundamental topics of Materials Engineering and Nanotechnology through a specific track consisting of 60 credits to be attended during the third year. Most of the compulsory courses given at the first Year of the Master in Materials Engineering and Nanotechnology are proposed in this track, with the exception of the subjects already covered in MEC courses (MECHANICAL BEHAVIOUR AND FAILURE OF METALS and MATHEMATICAL METHODS FOR MATERIALS ENGINEERING) and of the subject specifically oriented to chemistry (ADVANCED CHEMISTRY FOR MATERIALS ENGINEERING and ADVANCED MATERIALS). The interdisciplinary thesis work accounting for 20 further credits allows to achieve a total of 180 credits required to earn the DD title.

year I - MEC				
Code	SSD	Course Title	Semester	Credits
095837	ING-IND/13 ING-IND/32 ING-INF/04	CONTROL AND ACTUATING DEVICES FOR MECHANICAL SYSTEMS	1	9
095838	ING-IND/21	APPLIED METALLURGY	1	6
095839	ING-IND/09	ENERGY SYSTEMS	1	7
095840	ING-IND/16	ADVANCED MANUFACTURING PROCESSES	1	10
095841	ING-IND/14	MACHINE DESIGN 2	2	10
095842	ING-IND/13	MECHANICAL SYSTEM DYNAMICS	2	5
095843	ING-IND/12	MEASUREMENTS	2	5
095844	ING-IND/17	DESIGN AND MANAGEMENT OF PRODUCTION SYSTEMS	2	10
			Total	62

year II - MEC				
Code	SSD	Course Title	Semester	Credits
		OPTIONAL COURSES (selected among PSPA tracks found in MEC)	1-2	38
		Interdisciplinary thesis work *		20
			Total	58

year III – MAT					
Code	SSD	Course Title	Semester	Credits	CFU group
052517	ING-IND/22	MECHANICAL BEHAVIOUR AND DURABILITY OF POLYMERS	1	10	
054339	ING-IND/22	CORROSION ENGINEERING OF METALS AND CERAMICS	1	10	
093698	FIS/03	INTRODUCTION TO NANOSCIENCE (grounding)	1	5	
093699	ING-IND/22	INTRODUCTION TO MATERIALS SCIENCE (grounding)	1	5	

054335	ING-IND/23	SURFACE ENGINEERING	2	5	10
054336	ING-IND/22	SURFACE TECHNOLOGY	2	5	
054192	ING-IND/23	IMPIANTI E FENOMENI DI TRASPORTO	2	5	
089473	FIS/03	SOLID STATE PHYSICS	2	10	10
085888	FIS/03	FISICA DELLO STATO SOLIDO	2	10	
		OPTIONAL COURSES (selected from table 1)	1-2	5	10
		Interdisciplinary thesis work *			
				Total	60

\* The interdisciplinary thesis work is generally carried out starting from the second semester of the second year. The thesis may have one thesis advisor from the Mechanical Engineering Program or two co-advisors, from the Mechanical Engineering and Materials and Nanotechnology Engineering and Program. Once the thesis topic has been defined, the student is invited to discuss their choice with the Dual Degree program manager

At the end of the MAT-MEC double degree program, the student will be awarded with two Degrees (in Materials Engineering and Nanotechnology and in Mechanical Engineering). The Master degrees score will be determined on the basis of the weighted average score of exams plus an increment (ranging from -1 and 7 points on 110) for the thesis. The increment will be unique for both the Degrees, while the weighted average score will be determined:

- For the Master Degree in Mechanical Engineering, considering the weighted average score of the courses offered by the Mechanical Engineering program (100CFU) reported in table referring to Year I -MEC and Year II – MEC above.
- For the Master Degree in Materials Engineering and Nanotechnology, considering the weighted average score for the courses offered by the Materials Engineering and Nanotechnology program (60CFU) reported in table referring to Year III – MAT above and the courses to be defined (40 CFU) offered by Mechanical Engineering program.

## Remarks

Considering the selection of optional courses expected on second year of the Mechanical Engineering program, among the preselected tracks (PSPA) listed in current study plan, it is suggested that, on the basis of background knowledge acquired and on requirement of most relevant industrial sector, some tracks could be culturally more appropriate for the DD in Materials-Mechanical Engineering here proposed. The following tracks are considered more appropriate:

- Advanced Mechanical Design
- Advanced Materials and Technologies
- Ground Vehicles
- Machine Tools and Manufacturing Systems

Optional courses for year III MAT:

<b>Table 1 – OPIONAL COURSES</b>				
<b>Code</b>	<b>SSD</b>	<b>Course Title</b>	<b>Semester</b>	<b>Credits</b>
08130 0	ING-IND/21	PLASTIC DEFORMATION OF METALS	2	5
09160 7	ING-IND/21	MATERIALS FOR ENERGY	2	5
08043 6	ING-IND/21	MATERIALS FOR ELECTRONICS	2	5
09625 5	ING-IND/22	PHYSICAL PROPERTIES OF MOLECULAR MATERIALS		5
09160 5	ING-IND/22	PRINCIPLES OF POLYMER PROCESSING	2	5
08972 4	ING-IND/22	COMPOSITE MATERIALS FOR STRUCTURAL APPLICATIONS	2	5
09158 4	ING-IND/22	ADVANCED MATERIALS	1	10

## Admission

The applications for admittance to DD programme in Materials-Mechanical Engineer can be presented during the first semester of the first year by students that enrolled into either the Materials Engineering and Nanotechnology or Mechanical Engineering programmes in the first semester.

A call indicating the minimum admission requirement and the deadline for application will be issued each semester to all the entitled candidates.

The application should be sent by e-mail to: francesco.briatico@polimi.it with the following e-mail subject: Application for Internal Double Degree in Materials & Mechanical Engineering

- The following information should be provided in the attached documents:
- Motivation letter
- Final mark in the Bachelor Degree
- Curriculum Studiorum in the Bachelor programme (transcript of exams and thesis/project abstract, when available)
- Curriculum Vitae with clear indication of other competencies developed (beside the curriculum studiorum) and how they were developed, professional experiences.

## Contacts

Supervisors for M.Sc in Materials Engineering and Nanotechnology

- Prof. Francesco Briatico Vangosa (francesco.briatico@polimi.it)

Supervisors for M.Sc. in Mechanical Engineering:

- Prof. Andrea Bernasconi (andrea.bernasconi@polimi.it)

Stefano Turri (Dept. CMIC, Coordinator CS Materials Engineering)

Gaetano Cascini (Dept. MEC, Coordinator CS Mechanical Engineering)

Andrea Bernasconi (Dept. MEC)

Francesco Briatico Vangosa (Dept. CMIC)

Maurizio Vedani (Dept. MEC)