

# Doctoral Studies at Politecnico di Milano Engineering, Architecture, Industrial Design

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POLITECNICO DI MILANO



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# Rector's Foreword



Dear students and graduates

I would be very glad to have the opportunity of welcoming you to the Politecnico di Milano, Italy. The experience at our University and in our beautiful Country would be both pleasant and intellectually fulfilling. First established in 1863 in Milan, in the heart of productive Italy, the Politecnico di Milano is the oldest school for engineers in the Country and the only school of architecture and design in Lombardy Region. It is one of the leading technical universities in Europe, graduating engineers, architects and industrial designers through a variety of Laurea Magistrale (Master of Science) courses. Our university has always been based on quality and innovation in teaching and research, resulting in a prolific relationship with the economic and industrial world, through experimental research and technology transfer.

Still located in one of the most densely populated and high industrialized areas in Europe, its premises are spread over seven campuses: Milano-Leonardo, Milano-Bovisa, Como, Cremona, Lecco, Mantova, Piacenza. This "Politecnico Network" builds up a distributed university model, which provides for more direct relationships with students and for better interactions with local communities and private companies.

Currently around 42 000 students are enrolled at the Politecnico di Milano, where every year about 17% of the new architects, 25% of the new engineers and 63% of the new designers in Italy achieve their degree.

This brochure is intended to introduce the Doctoral programmes given at Politecnico di Milano, and to describe how Doctoral studies are organized and related with research carried out in our University.

Prof. Giulio Ballio



Politecnico di Milano  
Campus Leonardo

# Doctoral School Director's Foreword



**Professor Giancarlo  
Ferrigno, Director of  
Doctoral School**

Dear PhD candidates

Doctoral studies represent the highest level of University studies, and aim at developing the students' competences to undertake high level research in industrial and service enterprises, public bodies, research centres and universities, as well to promote start-up entrepreneurship. Doctoral studies at Politecnico di Milano are carried out, since the first eighties, within a high profile research environment and are characterised by a strong international scope and by intensive cooperation with the industry and with other research bodies. The availability of structured training programs and continuous quality monitoring ensures the highest educational standards are matched. Since 2000, in fact, a Doctoral School has been founded with the aim of coordinating, evaluating and monitoring the PhD Programmes in order to attain the higher standards of training.

While the single PhD programmes provide for research themes and facilities, field specific training and tutoring, Doctoral School provides complementary skill courses, as epistemology, research policy and research management, foundations of scientific communication etc.. It coordinates services for students such as e-mail permanent addresses, intranet, placement, etc., interacts with and coordinate the support of foreign candidates. Also a strong communication with enterprises and public bodies is carried out by the Doctoral School, to raise funds for students' scholarships and to provide them with the better possibilities of research on real world problems. For all these features, PhD at Politecnico di Milano is a challenging cultural experience, with hands-on possibilities and a worldwide career target. I hope to welcome personally you at the next academic year opening ceremony.

Prof. Giancarlo Ferrigno

# Politecnico di Milano, facts and figures

Politecnico di Milano is the largest Technical University in Italy, providing high education and undertaking research activities in Engineering, Architecture and Industrial Design.

Permanent staff includes more than 1150 professors, organised in 9 Schools, 6 of them grouping different areas of Engineering Sciences, the other 3 relating to architecture, land and urban planning and industrial design.



Italy, Lombardy and the network of Politecnico di Milano campuses

Each school includes a number of Study Courses, where teaching is articulated into three main academic steps:

- the “Laurea” (equivalent to B.Sc. - Bachelor of Science): a first step, 3-years degree providing general scientific contents and methods as well as specific professional skills.
- the “Laurea Magistrale” (equivalent to M.Sc. - Master of Science): a 2-years higher degree providing high qualification in specific fields.
- the “Dottorato di Ricerca” (equivalent to PhD - Doctoral Programme): a 3-years course following the Laurea Magistrale and providing high

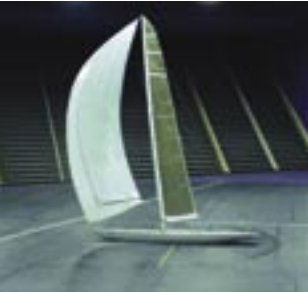
level specialistic and complementary teaching as well as training to research activity.

The number of PhD students is almost equal to that of professors, thereby providing a well balanced ratio between demand and offer of training and tutoring resources, but still allowing a significant potential for further rise in the number of students.

<b>Schools</b>	<b>Laurea (B.Sc.) Courses</b>	<b>Laurea Magistrale (M.Sc.) Courses</b>
<b>I School of Engineering</b> (Ingegneria Civile, Ambientale e Territoriale)	<b>Civil Engineering</b> <b>Environmental and Land Planning Engineering</b>	<b>Civil Engineering</b> <b>Environmental and Land Planning Engineering</b>
<b>II School of Engineering</b> (Ingegneria dei Sistemi)	<b>Biomedical Engineering</b> <b>Management, Economics and Industrial Engineering</b> <b>Mathematical Engineering</b> <b>Physics Engineering</b>	<b>Biomedical Engineering</b> <b>Building Environment Management</b> <b>Management, Economics and Industrial Engineering</b> <b>Mathematical Engineering</b> <b>Physics Engineering</b> <b>Public Administration Engineering</b>
<b>III School of Engineering</b> (Ingegneria dei Processi Industriali)	<b>Chemical Engineering</b> <b>Electrical Engineering</b> <b>Materials Engineering</b>	<b>Chemical Engineering</b> <b>Electrical Engineering</b> <b>Industrial Product Design and Engineering</b> <b>Materials Engineering</b> <b>Nuclear Engineering</b> <b>Prevention and Safety Engineering in Process Industry</b>
<b>IV School of Engineering</b> (Ingegneria Industriale)	<b>Aerospace Engineering</b> <b>Energy Engineering</b> <b>Mechanical Engineering</b> <b>Transportation Engineering</b>	<b>Aeronautical Engineering</b> <b>Energy Engineering</b> <b>Industrial Product Design and Engineering</b> <b>Mechanical Engineering</b> <b>Space Engineering</b>
<b>V School of Engineering</b> (Ingegneria dell'Informazione)	<b>Automation Engineering</b> <b>Computer Engineering</b> <b>Computer Engineering (full on-line course)</b> <b>Electronics Engineering</b> <b>Telecommunications Engineering</b>	<b>Automation Engineering</b> <b>Computer Engineering</b> <b>Electronics Engineering</b> <b>Telecommunications Engineering</b>

<b>Schools</b>	<b>Laurea (B.Sc.) Courses</b>	<b>Laurea Magistrale (M.Sc.) Courses</b>
<b>VI School of Engineering</b> (Ingegneria Edile/Architettura)	<b>Building Engineering</b> <b>Building Science</b>	<b>Building Engineering</b> <b>Building Engineering/</b> <b>Architecture</b> <b>Building Environment</b> <b>Management</b>
<b>I School of Architecture</b> (Architettura e Società)	<b>Architecture Science</b> <b>Building Production</b> <b>Architecture</b> <b>Environmental Architecture</b> <b>Urban Design</b>	<b>Architecture</b> <b>Building Environment</b> <b>Management</b> <b>Urban Planning and Policy</b> <b>Design</b>
<b>II School of Architecture</b> (Architettura Civile)	<b>Architecture Science</b> <b>Constructions Architecture</b>	<b>Architecture</b> <b>Constructions Architecture</b> <b>- Architecture</b>
<b>School of Design</b> (Design)	<b>Communication Industrial</b> <b>Design</b> <b>Fashion Industrial Design</b> <b>Furniture Design</b> <b>Industrial Design</b> <b>Interior Design</b>	<b>Communication Design</b> <b>Fashion Design</b> <b>Furniture Design</b> <b>Industrial Design</b> <b>Industrial Product Design and</b> <b>Engineering</b> <b>Interior Design</b> <b>Product Service Systems</b> <b>Design</b>

# Research at Politecnico di Milano



**Boundary layer wind tunnel:  
tests on the model of an  
"America's cup" ship**

The mission of the Politecnico di Milano is to develop high level research activities in an international context and at the same time to contribute to the dissemination of knowledge towards the world of industry, thereby providing a substantial contribution to the innovation and transformation of the modern society.

A brilliant example of the success of such a policy has been the Nobel Prize winner for chemistry in 1963, Giulio Natta, who spent his whole career as a professor at Politecnico di Milano, studying polymers in collaboration with the Montecatini Company.

Today Politecnico di Milano is one of the world leading research centres, characterized by a mix of excellent theoretical foundations and outstanding research infrastructures.

Research activity at Politecnico di Milano is based on **17 Departments**, each one being autonomous in defining its research priorities, promoting self-funding through co-operations with industry, public administration and other bodies, owning and developing research facilities, establishing links and synergies with other research centres. A multidisciplinary approach to research is fostered by the presence of several inter-departmental centres, coordinating different research approaches taken by the Departments within common research fields.

The **Politecnico Foundation**, established 2002, acts aside the University to foster and improve the integration between academic and industrial research as well as to increase the ratio between private and public funding to research undertaken at Politecnico.

The Politecnico di Milano is investing extensively on exploiting the results of research being carried out within the university, in particular by supporting and fostering the registration of new industrial patents. The results of this policy are witnessed by about 50 new patents in the last few years, mainly related to high-tech research fields. Moreover, the university has established a policy to foster the creation of new entrepreneurial initiatives by its researchers, through the creation of spin-offs and start-ups in several high-tech sectors.

## Research Areas

The Politecnico di Milano is currently concentrating its research effort in 10 strategic research areas:

**Environment**, where mathematical models, simulation tools, methodologies for monitoring natural and industrial risks are being developed, in particular with respect to environmental safety, planning and management.

**Bioengineering**: in this field, basic biotechnological research is complemented by industrial applications in the form of development and transfer of innovative products and technologies to industry and hospitals.

**Product innovation**: research in this field deals with innovation processes and their results. A School of Industrial Design was created within Politecnico di Milano, to foster new development of research in this area.

**Materials and their technologies**: research in this area deals with a number of applications, ranging from micro and nanostructures up to composites, polymers alloys and metallic materials.

**Cultural heritage policy and management**: research is related to diagnostics, preservation and restoration of buildings and “movable” items, studying innovative methods for their enrichment. This research field witnesses the Politecnico’s endeavour not to neglect the humanistic side of scientific education.

**Building policies and management**, whose objective is to computerize data regarding single buildings, urban areas and old town centres, as well as the electronic dissemination of the results.

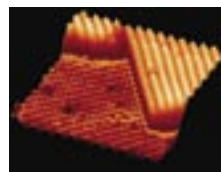
**Citizen, enterprises and governance**: the area is related to the evolution of the economic, industrial and social context; particular attention is paid to new organizational models, internationalization, environmental issues and management of public administrations.

**Information Society**: research field where the Politecnico undertakes research, training and technology transfer to companies, for the development of new technologies and the study of their economic, management and competitive implications.

**Transport Systems**: this is a priority research area for Europe. Research undertaken in this field covers all transportation modes (automotive, railway, aeronautics, aerospace engineering and yacht design) as well as transport management issues, taking advantage of the availability of some outstanding research facilities like the boundary layer wind tunnel and the laboratories for safety in transport systems.



Crash tests on a helicopter cabin with dummy at Politecnico di Milano - Crash Lab



Atomic resolution image of a Silicon (111) surface, as obtained by Scanning Tunnel Microscopy (STM). From work carried out by the Inter-University Research Centre L-NESS recently constituted between the Department of Physics of Politecnico di Milano and the Department of Material Science of the Università degli Studi Milano-Bicocca

**Energy:** in this field innovative technologies for energy generation are developed, with special attention to minimizing the environmental impact.

Research at Politecnico di Milano strongly relies on the use of advanced laboratories and other research infrastructure, covering a wide range of areas and applications. The wind tunnel, research facilities for safety in ground and air transport, laboratories for architectural design and the brand new experimental devices for nanoengineered materials and surfaces are only few examples of the wide network of recent achievements by the university. More detailed information on these and many other research facilities may be found on the Departments' web pages, that can be reached from Politecnico homepage [www.polimi.it](http://www.polimi.it).

<b>Departments at the Politecnico di Milano</b>
<b>Aerospace Engineering</b>
<b>Architectural Projects</b>
<b>Architecture and Planning</b>
<b>Bioengineering</b>
<b>Building and Environment Science and Technology (BEST)</b>
<b>Chemistry, Materials and Chemical Engineering "Giulio Natta"</b>
<b>Electrical Engineering</b>
<b>Electronics and Information</b>
<b>Energetics</b>
<b>Hydraulic and Environmental Engineering, Road Infrastructures, Surveying</b>
<b>Industrial Design, Arts, Communication and Fashion (INDACO)</b>
<b>Management, Economics and Industrial Engineering</b>
<b>Mathematics "Francesco Brioschi"</b>
<b>Mechanics</b>
<b>Nuclear Engineering</b>
<b>Physics</b>
<b>Structural Engineering</b>

# Doctoral studies at Politecnico di Milano, an overview

The Doctoral Programmes of Politecnico di Milano aim at developing the professional competences in order to undertake high level research in industrial and service enterprises, public bodies and universities.

The Doctoral Programmes provide a selected number of highly qualified graduates, endowed with a solid preparation and keen intellectual curiosity, with the opportunity of acquiring a high degree of professional expertise in specific scientific, technological, social and economic fields.

PhD graduates are capable of carrying out research projects and at the same time develop during their period of study new knowledge on scientific frontiers that can be directly transferred to professional activities.

The distinguishing features that make the Doctoral Programmes of Politecnico di Milano particularly attractive are:

- High level and broad spectrum teaching and training activities, bringing outstanding possibilities for the development of the trainee researcher's career.
- A high profile and internationally relevant faculty staff and research environment, from which the Doctoral student will benefit.
- Availability of structured training programmes, where introductory, main and elective courses are well integrated with research activities and complementary training.
- Continuous monitoring of the training programme quality: each Doctoral Programme is periodically reviewed and evaluated by international experts in the field, while an Advisory Board ensures that the programmes fit the needs of the non-academic world. The effectiveness of the Doctoral Programmes in matching the trainees actual needs is assumed by means of web based questionnaires.
- A wide network of cooperation with industry and with other research bodies, that will foster the transfer of the innovation produced by the Doctoral theses into applications, also providing opportunities for new patents.
- A strong international attitude, open to cooperation with universities and research centres from countries outside Italy, that will also stimulate students to participate in study periods abroad.

## **The Doctoral School of Politecnico di Milano**

The Doctoral School of Politecnico di Milano was established in year 2000, with the aim of co-ordinating the Doctoral Courses given at the University. The main functions of the Doctoral School are:

- To ensure and certify the quality of each Doctoral Course, also relying on the support of the Advisory Committee and of international reviewers.
- To co-ordinate educational initiatives common to the Doctoral Courses, like complementary skills training.
- To foster collaboration with private and public bodies in order to promote and finance research projects and to provide ground for research applications and dissemination.
- To promote the internationalization of the Doctoral Courses.
- To manage administrative issues.

## **The Advisory Board**

The Advisory Board of the Doctoral School is composed by distinguished representatives of industry, economy and culture, who are appointed by the Rector of the Politecnico di Milano.

The role of the Advisory Board is to support the Doctoral School in pointing out the request for advanced competencies in the industry as well as in public bodies and research centres, and to review the Doctoral Programmes in order to assess their quality and their effectiveness in addressing real societal needs.



PhD degree awards' ceremony

# Structure of the Doctoral Programme

The Doctoral training programme at the Politecnico di Milano is organized into 180 ECTS credits (three years), each credit being equivalent to 25 hours of student work. Credits are divided into four areas:

- a. **Introductory training:** courses that provide the preliminary knowledge needed for studying subjects in the field of a given Doctoral Programme.
- b. **Main research training:** consists in courses specifically designed for PhD students. These courses deal with the main scientific problems, theories and approaches relevant to the Doctoral Programme, and form the core of the training programme.
- c. **Elective training:** various kinds of activities (courses, seminars, summer schools, conferences and workshops, personal investigation) allowing the student to develop in-depth knowledge on the specific issues related to his/her Doctoral Thesis.
- d. **Development of the Doctoral Thesis:** research activities on a topic of industrial, social, cultural and economic relevance, producing new knowledge in a highly distinguished scientific or technological field.

For each Doctoral Programme, a **Faculty Committee**, composed by professors and widely recognized experts in the field, has the role of designing and planning educational and research training activities for the trainees and to assess their achievements by means of periodical meetings with the students (at least one per year).

The Faculty Committee, in agreement with the student, appoints a **Tutor** for each Doctoral student. The Tutor supports the student in designing and managing her/his own **research programme**, taking full advantage of the educational offer available at the Politecnico di Milano as well as of training and research opportunities abroad. The training programme is submitted to a periodical review by the entire Faculty on occasion of the periodical meetings with the student.

The Faculty Committee also appoints a **Supervisor**, whose role is to follow and monitor the development of the student's Doctoral Thesis. Finally, the student benefits from the ongoing interaction with the Research Team working in the Doctoral Thesis field, which normally

includes researchers from the Politecnico di Milano staff as well as experts from industry and international experts.

The **Doctoral degree** is awarded upon the completion of at least three years of study and research and after passing the final examination, where the student defends her/his Thesis work in front of an external commission of experts, often including foreign university staff. Wherever possible, the criteria set out by the Confederation of European Union Rectors' Conferences in order to award the **European Doctoral degree** are followed within the training programme and the final examination.

### **Complementary training**

Besides specific courses provided as introductory, main and elective training within each Doctoral programme, some complementary training courses are offered to all PhD students. These courses are directly managed by the Doctoral School of the Politecnico di Milano, under the assumption that, in order to develop a complete attitude to the research work, a Doctoral student should also acquire knowledge concerning the ethical and practical implications of being a researcher, regardless of the specific research field where his/her career will develop.

Complementary training courses presently given are:

- **Research Management**, dealing with research strategies and organization, admission to funding, dissemination and protection of the results, high technology start-ups. This course is intended to provide the students with information concerning how different bodies (enterprises, research centres, universities) plan their own research strategies and manage their research teams and projects.
- **Research policy**: a cycle of seminars where stakeholders from national and international research institutions are invited to help the students understand why, where and how the guidelines for research are formulated and how researchers may contribute to this process.
- **Epistemology of scientific and technological research**: a cycle of conferences where well known experts on epistemology, social sciences and history are invited and partnered with faculty members of the Politecnico di Milano. The course is intended to teach the students how to place their specific research activities within a more general process of knowledge generation and within the economic and societal context.
- **Scientific and technical communication**: is intended to provide the students with the methods and skills to communicate at the scientific and technical level. The course covers written communication (writing of a scientific or technical paper and of a thesis) as well as oral communication (presentation to meetings and conferences).

# Doctoral Programmes given at Politecnico di Milano

A concise description of the subjects of all Doctoral Programmes offered by Politecnico di Milano is reported below. More information can be obtained on the web page:

<http://pcsiwa12.rett.polimi.it/~phdweb/eng/corsi/elencocorsi.htm>  
(follow the link to the name of the Doctoral Programmes of your interest).

## **Aerospace Engineering**

The aim of the course is the acquisition of the high level competence required to carry out innovative research and/or state of the art advanced applications in industries, public or private research centres, universities, public and service companies in the area of aerospace engineering, including all the fields associated to it. The level of the course should allow graduates to compete in a European and international environment. The Doctoral thesis is developed within the Department of Aerospace Engineering or, in some cases, in other institutions, always in close contact with the Department.

## **Applied Mathematics**

The PhD Programme in Applied Mathematics, run by the Department of Mathematics, aims at training high level researchers in advanced areas of applied mathematics. In order to provide the students with the skills for a deep understanding of real-world phenomena and knowledge of mathematical tools for their description and for design, the teaching activities include both modeling and methodological aspects: courses are offered in the area of natural sciences, in variational, differential and stochastic models, in numerical analysis and simulation, in operations research and computational and algorithmic methods. The PhD thesis consists in original and high standard research work in one of these areas. The thesis is developed with the advice of a supervisor, in three or four semesters in average. Further information can be found at the web site of the Department of Mathematics <http://www.mate.polimi.it> (follow the link "Dottorato di Ricerca").



**CASIMIRO** (Cheap Automated Stereo Images Environment Identification Rover), a six wheels rover for space exploration developed at the Dept. of Aerospace Engineering of the Politecnico di Milano

## Architectural Composition

The course has been designed with a unique approach emphasizing a cultural orientation to the profession. Its purpose is to provide architects with a general point of view and a solid historical/critical training, enabling them to approach the themes that are central to the evolution of the city and the territory with sound knowledge and technical preparation. The training will take place by means of research. Seminars will deal with the leading figures on the international scene. Major weight will be given to the candidates' theses. As it is the case in the other arts, composition is understood as a body of conceptual and technical bases foregoing the architectural project, and to which it refers.



**The Roman Theatre in Brescia: restitution and rehabilitation project**

## Architecture, Urban Design, Conservation of Housing and Landscape

The purpose of the course is to train professionals and researchers to have a better and more specific awareness of the issues that are today involved in the transformation both of our physical surroundings and of our living spaces, to develop skills in the sensible use of our (environmental and cultural) resources and in planning sustainable patterns of development, thereby being especially respectful of the new social needs brought about by economic and cultural globalization. Given the complex nature of the issues involved, any didactical approach must be multi-disciplinary. Yet, at the same time, it must not forgo the need for synthesis and planning experimentation within the specific sectors of this Doctorate. The Doctoral Programme therefore includes three distinct but strongly interdependent “training itineraries”:

- 1) planning and designing residential spaces in contemporary urban contexts;
- 2) urban and landscape planning;
- 3) preservation of building/architectural heritage.



**A researcher from Politecnico di Milano taking part to a parabolic flight on a NASA KC130 airplane. From a research carried out in cooperation between the Department of Bioengineering of the Politecnico di Milano and MIT - Man Vehicle Laboratory.**

## Bioengineering

The Doctoral Programme in Bioengineering trains graduate students through a strong interdisciplinary education on engineering, mathematics, medical and biological knowledge to develop high level bioengineering problem-solving abilities inside a research group or in a private or public industrial context. Students work in fields currently ongoing at the Bioengineering Department of Politecnico di Milano: modeling and analysis of physiological data, signals and systems; biomedical image processing; technologies and instrumentation for movement analysis, rehabilitation, ergonomics and sports; therapeutic devices and life support systems in cardiology and cardio/surgery; design and assessment of prostheses; surgery optimization with modeling; cardiovascular fluid dynamics; molecular, cellular and tissue engineering for biomaterials and prostheses; bioinformatics. Stage periods in distinguished research institutes in Italy and abroad are an important feature of the student training.

## Building Systems and Processes

The main research areas investigated in the Doctoral course are the following:

- technological innovation in building production, with attention to buildings' performance and quality, pursued through methods and tools consistent with environment and energy sustainability;
- innovation in process management in the construction field, with attention to private and public clients and contractors' needs.

Research activities are developed in cooperation with:

- advanced Italian and foreign building companies;
- Italian and European research Centres (ITC/CNR in Italy, CIB, Rilem, CSTB and others, abroad);
- Italian, European and international standardization bodies (UNI in Italy, CEN and ISO abroad);
- Italian public clients, developers and real estate managers.



3D digital reconstruction of the castle in Abbiategrasso

## Design and Technologies for the Exploitation of Cultural Heritage

The doctorate targets the training of professionals inclined towards the management, communication, and monetary estimation of cultural assets by offering a didactic programme covering the fields of technological process and product innovation, strategic planning, and organization.

The training programme develops and transfers well-developed approaches as well as integrated intervention methods through the curriculum and research areas covered. The integrated methods concentrate on project design, on products and services targeted towards culture, on the identification of resources, and on the realization and management of specific interventions. Emphasis is given to the notion of “cultural heritage”, which can be identified as goods such as furniture, buildings, materials, immaterial assets, the environment, both public and private, present throughout the territory.

Characteristic elements of the programme include the involvement of well-known professors and institutional and professional bodies that operate in the field of cultural assets. The area where the doctoral programme is located (Mantua and other well known artistic cities, Sabbioneta and other smaller provincial centers, the Mincio river with its park and the fluvial river basin of the Po) makes up an environment fostering experimentation with cultural assets evaluation with the help of technological innovation from design to communication.

## Electrical Engineering

The main goal of this Doctoral Programme is, first of all, to give the PhD student a very good knowledge of mathematics and physics, secondly to make him an expert in one of the following research fields: circuit and electromagnetics, power systems, power electronics, measurements. The purpose is to insert the student in any research body such as an R&D department of a production or services company. The first field is intended to provide the basic knowledge of methods in electrical engineering for power applications. The second one involves studies in electrical energy production and transmission, liberalization of power markets and power quality in distribution systems. The third field deals with machines and converters, with the purpose to reach robustness, good dynamic response and drive control, low prices, devices optimization. Finally, the fourth field of research concentrates on the fundamentals of metrology, mainly on the characterization of modern measurement systems based on complex structures of digital signal processing.



Experimentalequipment to study laser radiation driven combustion processes

## Energy

The following subjects are considered in the Doctoral Programme:

- Combustion of solid, liquid and gaseous fuels.
- Fluid machinery using water, steam or gas as working fluids.
- Energy systems and central power stations.
- Energy activities and ambient safeguard.
- The hydrogen technology.
- Carbon dioxide control and sequestration.
- Energy in buildings.
- Aerospace propulsion.
- Heat transfer and advanced heat exchangers.

## Geodesy and Geomatics

The doctorate in Geodesy and Geomatics deals with a set of subjects including space geodesy, earth watching, gravity field determination, global reference frames maintenance, the classical techniques of local surveying (down to the scale of architecture) for mapping and/or control purposes, up to the problem of the representation of results and their filing by means of modern e-tools, particularly by geographic information systems in their various forms.

The courses given by the Doctorate School range from basic courses to advanced specialized subjects. They start with geomatics and geostatistics, to supply a good background of data analysis tools, looking at the more advanced techniques related to stochastic processes and random fields.

The new measuring techniques like GPS, digital cameras, spectrometers, laser scanners etc. are illustrated together with the corresponding data analysis methods. Very specific and specialized courses are provided for such matter like space geodesy, gravity field determination, spatial informatics systems, computer graphics.



Satellite image of the 2002 eruption from the Etna volcano

Students obtaining the degree of Doctor in Geodesy and Geomatics do find employment both in the university and in research centers, in advanced and specialized industry branches, as well as in public agencies at national or regional level.

### **Industrial Chemistry and Chemical Engineering**

The Doctoral Programme in Industrial Chemistry and Chemical Engineering is designed for students aiming at getting deep expertise in research activities as well as in the development and design of chemical processes, including all the relevant aspects involved in energy, environmental and safety processes. The Programme is the ideal extension of the Laurea Magistrale degrees in Chemical Engineering, Materials Engineering, Industrial Chemistry and Chemistry but is also open to graduates in other scientific disciplines. The general topic for the Doctoral Programme in Industrial Chemistry and Chemical Engineering is the application of the chemical and physical knowledge to all the activities related to the synthesis, design, production and transformation of chemical substances. This study involves not only the processes of synthesis and transformation of materials, but also the associated plants, from laboratory tests to pilot plant experiments, with the related energetic, safety and environmental problems. The goal is to give the Research Doctor the tools to design and manage industrial processes, and to allow him to develop new technological applications in a self-sufficient way and to create and characterize new products and services.

### **Industrial Design and Multimedia Communication**

The Doctoral Programme's final objective is the training of a high profile researcher, able to develop research either in academic or industrial contexts. Aim of the activities carried out in the course is the production of specific researches by the individual students. This work is accompanied and supported by the research activity carried out from the students in the Research units and by crossing activities like classes, labs and thematic seminars.

The doctorate programme is broken down into two directions:

- Industrial design, intended as a discipline acting within the industrial culture and accompanying its transformations.
- Multimedia communication including from the design of interfaces to the design of communication systems either with conventional technologies or with multimedia-multisensorial ones.



**Study of a restraint to be used during experiments' performance in microgravity inside the Columbus Laboratory, International Space Station (research "MEEMM Operational study" for ESA - European Space Agency). From the doctoral thesis in Industrial design and Visual Communication: "Habitability in space: Design for microgravity"**

## Information Technology

The Information Technology Programme offers doctoral studies in the areas of automatics, electronics, computer engineering and telecommunications. Foundations such as operation research and applied logic are included, as well as applications e.g. in robotics, ecology and virtual museums.

Experimental and applied research is performed in the labs. Intense industrial links introduce students to technology leaders.

The principal subjects of study and research are as follows:

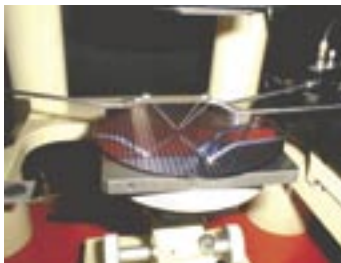
- *Automatics*: system and control theory, model identification, data analysis for prediction and filtering, industrial automation; modeling, simulation and control of industrial processes; modeling, management and control of energy systems, robotics and mechatronics, automation in aerospace and transportation systems, operations research, combinatorial optimization, models and algorithms for planning and management of services, decision support systems, environmental modeling.
- *Electronics*: design of electronic devices, discrete and integrated circuit design, characterization measurements of devices and materials for electronics, study of electronic transport in solid state devices, sensors, optoelectronics, optical media and optoelectronic devices, analog and digital signal processing, radiation detectors and applications, simulation and CAD for circuits, neural and non-linear networks.
- *Computer Engineering/Science*: computer architecture, electronic processing systems, VLSI digital systems, computer networks and parallel systems, web based computer systems, distributed systems and mobile systems, programming languages and compilers, operating systems, software engineering, man-machine interaction, multimedia and virtual reality, theory of computation, of algorithms and of formal languages, applied mathematical logic, artificial intelligence, knowledge engineering, robotics, artificial vision and perception, computer graphics, information systems, data bases, systems performance, security and reliability evaluation, industrial informatics, educational technologies.
- *Telecommunications*: information theory, radio transmission systems, data storage systems, TLC networks, signal detection and estimation, radio communication systems, cryptography and data security, internetworking, mobile and fixed networks, service quality, antennas and propagation, electromagnetic compatibility, microwave and photonic circuits, optical signal processors, optical measurements,



Diving stabilization and control in ROV/AUV submarines

left  
Probe station for on-wafer device testing

right  
Home page of the web site "Edvard Munch. Graphic in Berliner Kupferstichkabinett", designed for Staatliche Museen zu Berlin



digital signal processors, neural nets classifiers, video signal coders, scene analysers, remote sensing, synthetic aperture radar, geophysical prospecting.

## Interior Design

Themes and research problems addressed by the Doctoral Programme in Interior Design are:

- *Interiors Architecture and Furnishing*: theory and history; basic principles of architecture and interior design; evolution of content, methodologies and planning concepts in different periods and cultural



Archive-Museum of the polytechnic culture at Città Studi, Milano (inner view of the exhibition hall)

environments, with specific thorough examination of actual problems concerning architecture and industrial design;

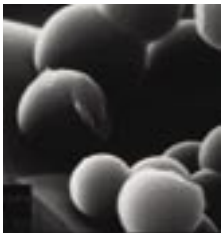
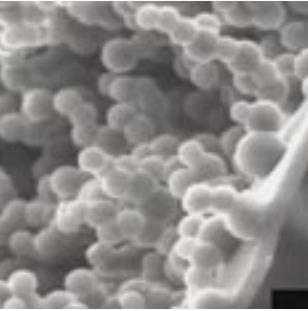
- *Housing models*: history, new trends and future orders of housing (private and common dwellings; public, company and autonomous working precincts; cultural, social, sanitary, sports and leisure time and open urban areas services and structures) connected to social, economical, cultural systems evolution, to technological and informational innovation, to formal and aesthetic problems;
- *Architectural space*: structure, composition and quality of urban and building interior space, its connection with the context and its organization; nature and features of sheath and space fitting, and theirs connections;
- *Environment*: features, methods and tools for planning, simulation and monitoring of micro-climate and environmental comfort: study of energy, lighting, aerodynamical, material and ergonomomy aspects;
- *Furnishing elements*: typology, morphology, technology and space, materials, colour, tactile and ergonomic values of furnishing and objects; analysis of their connections and relationships with space and covers systems.

## **Management, Economics and Industrial Engineering**

The Programme aims at developing professional skills, dedicated to performing high quality research activities within industrial companies, service companies, public corporations and universities. In particular, the Programme provides students with advanced competencies in business economics, finance, organisation and management; industrial, real and monetary and regional and urban economics; logistic-production system management.

## **Manufacturing Systems and Processes**

The main target of the Programme is to provide PhD candidates with specific training in the industrial engineering disciplines and to strengthen their research skills in the industrial and academic contexts. In particular, the Programme gives relevance to the problem of optimal transformation of raw materials into products and addresses the problems related with the introduction, use, evolution and continuous improvement of technologies and systems required during the entire product life cycle. The main subjects of the Programme are: manufacturing, production systems, product lifecycle management and quality. The professional skills acquired with this Programme are of great interest to industrial companies (in the areas of R&D, innovation management, product/process/system design and management and quality management), service companies (in the areas of service design, quality management and service automation), consulting companies (in the areas of supply chain organization, operations design and management, service design and quality) and to the research field (universities and national research councils).



**SEM images of graphitic material**

## **Materials Engineering**

Purpose of the courses of this Doctoral Programme is to provide PhD students in materials engineering first with a common, basic knowledge followed by a specializing training in specific fields. The objective is to combine the theoretical knowledge with the requirements by technology in order to prepare a qualified researcher who can lead the design, manufacturing and use of traditional and/or new materials.

The courses offered face advanced issues both in the main and elective courses. Different curricula are offered which will be activated on the basis of the decisions of the faculty. The lessons include, when necessary, the discussion of theoretical, experimental or numerical aspects. Seminars and workshops are organized with invited speakers from international Institutions. The greatest attention is paid to make the student able to use the most modern facilities available in the Politecnico di Milano or in other research laboratories. Main disciplinary areas involved are biomaterials, polymers and composites, cements and ceramics, corrosion and durability of materials, metals, structure, properties and microscopic theories of materials, materials for electronics, photonics and sensors, electrical and magnetic properties of materials, surfaces and coatings, materials for industrial design.

## Mechanical Systems Engineering

The Programme addresses all topics related to the modeling, functionality, durability and reliability of mechanical systems, and to their interaction with control and actuation systems. Main research fields covered by the Programme are: vehicle mechanics, dynamics and control of mechanical systems, mechanical vibrations and noise, monitoring and diagnostics of rotating machines, robotics, biomechanics, structural reliability, structural optimization, design and drawing methods in industrial engineering, design for eco-compatibility.

Research work is carried out by the PhD students in strong connection with industrial research and finalized to actual industrial needs, as attested by the fact that in year 2004 nine scholarships over a total of twenty were funded by industries.

## Physics

The PhD course on Physics is finalized to fundamental and applied physics always keeping in mind the perspectives of the cross-fertilization with Engineering. This is why the course is largely based on experimental activity with a strong training programme in the laboratories and with the personal involvement of the student in an original thesis based on experimental work.

As far as content is concerned, the activities go along two main lines that are strongly interlaced: laser physics and solid state physics with attention to nanotechnologies. In laser physics attention is mainly given to femtosecond physics with applications, biological applications of laser and telecommunication issues. In solid state physics the main fields are semiconductors, magnetism and spintronic. In solid state physics the work is not only done at the Politecnico laboratories but also at the main Synchrotrons (in particular at the European Synchrotron Radiation Facility in Grenoble).

## Preservation of Architectural Heritage

The Doctoral course covers a wide spectrum of subjects in which theory and practice melt together in order to foster advanced research with multidisciplinary bias as necessary for more and more productive results in the field of conservation and maintenance of historic buildings.

Courses and experimental activities concern the history and theory of restoration, the constructive techniques of the historic heritage, the study of non destructive investigation for the diagnosis of decay of historic buildings, the investigation on the appropriate and non invasive techniques for repair and strengthening, also including the prevention techniques for the safety of buildings in seismic areas, research on materials of historic buildings, history of architecture textbooks and literature, methodology of the architecture archaeology, techniques for the survey and storage of data, construction physics and installations in historic buildings, performance analysis, principles and techniques of the restoration project, codes and rules concerning the cultural heritage, environmental protection, history and conservation of historic gardens.



Wind tunnel tests on a model of a High Speed train, to define the effect of crosswinds on ride safety



Ultra vacuum machine

## **Programming, Maintenance, Rehabilitation of the Building and Urban Systems**

The Programme aims at training researchers, managers, and design professionals being able to set out innovative design strategies of organisation, management, maintenance, rehabilitation, and programming of the building facilities as well as to promote and coordinate in this specific field high qualification research activities, projects, programmes, and controls in compliance with the new European Union regulatory procedural and technical context and with the subsequent future developments of the relevant operative context and sector market.



The "Torrazzo" in Cremona: one of the historical building being investigated in the Doctoral Programme on Preservation of Architectural Heritage

## **Radiation Science and Technology**

The main objectives of the Doctoral Programme include the development and exploitation of radiation sources in different areas such as physics of condensed matter and new materials, nuclear plants, instrumentation, industrial and medical diagnostics, radiation protection, radiotherapy and radiochemistry. The approach is typically interdisciplinary and aims at i) acquainting the student with the state of the art in his specific field, so as to allow him pursuing his research activity, ii) developing models or experiments towards a growth of scientific and technological knowledge, iii) conceiving and verifying new technological solutions meeting specific industrial requirements and constraints.

## **Sanitary-Environmental Engineering**

For a typically interdisciplinary topic such as Environmental Engineering, teaching activities are very important, mainly for the wide cultural base being required to perform research in the field. Specific training courses in biology and chemistry, environmental modeling, environmental laboratory and monitoring, environmental reactor dynamics and statistics applied to environmental engineering, are offered.

The full range of research themes offered by the PhD Course will cover the following list, in which PhD theses will be developed.

- Water supply technology and treatment, disposal and reuse of wastewater.
- Production, collection, recycling and disposal of solid waste and sludge.
- Phenomenology of atmospheric environment and treatment of gaseous emissions.
- Contaminated soils and their remediation, groundwater protection and treatment.



Digital Photogrammetry: QuickBird image of Venice

## **Structural, Seismic and Geotechnical Engineering**

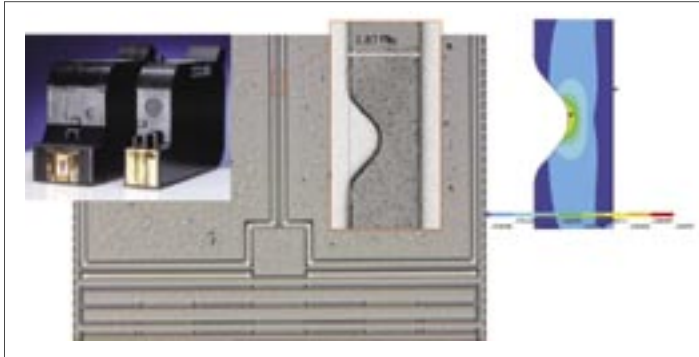
Structural-Seismic-Geotechnical Engineering includes the disciplines and techniques aimed at understanding, describing and controlling the mechanical behavior of the structural materials, of the soils, of the

buildings and of their interaction with the environment. It is a very interdisciplinary context, which refers to:

- the structural materials (concrete, steel, wood and bio-compatible materials);
- the constructions and their safety (tall buildings, bridges, monumental buildings, dams and tunnels);
- the loading conditions (wind, earthquake, vibrations and temperature);
- the thrust due to retained earth;
- the landslides.

Therefore, the primary objective of the PhD course is the advancement of the knowledge in a variety of sectors, such as:

- new or innovative structural materials and structures;



**Mechanical  
characterization of  
polysilicon**

- building safety with reference to highly-variable loads;
- ground stability, with reference to both shallow and deep foundations.

In order to achieve this objective, the PhD course gives the candidates the possibility of doing advanced scientific research, taking advantage of the specific methods and approaches typical of Structural Engineering, and of the wide spectrum of the issues treated by Seismic and Geotechnical Engineering. Though Structural-Seismic-Geotechnical Engineering is traditionally deeply-rooted in Civil Engineering, the variety of the topics and the generality of the research methods allow the candidate to manage many complex problems found in other fields, like Architecture and Industrial Engineering.

## **Technology and Design for Environmental Quality in Buildings and Urban Context**

Aim of the Doctoral course is to provide the students with the methodological instruments and knowledge necessary for a mature professional profile, able to develop and apply strategies and systems either for building construction (innovative techniques for an industrialized production of components) and built urban context (completions, redesign of the spatial relations between public and private use, and relevant networks of infrastructures). The training path aims at leading the graduate to the full competence in the field of architectural eco-compatible advanced techniques, improving his/her

knowledge of the design process of building components and systems, as much as sustainable management of the deep changes in the urban built environment. All these issues are articulated in two specific training fields or knowledge levels (the building scale and the urban scale), interconnected and characterized at conceptual level, grown from a common root of environmental energy control studies.

### **Urban and Architectural Design**

The main subject of the research addressed by the Programme is “the scale of the contemporary city” in its multiple aspects, specifically with



**Photovoltaic integration in the architectural design: the example of Villanova di Camposanpiero, Padova, 2001.**

respect to the multiscalarity of architectural organizations in terms of scales of inhabitability and the size of urban prostheses between fields of contextual texture and networks of non-contextual connections with the relevant interchange points.

In other words, what is addressed is the innovative correlation between the global and local scale and, as a consequence, the analysis of three correlated issues:

- multiscalarity of the architectural project on a local scale, both in historic centres or consolidated cities and in periurban areas where the breakdown of the countryside asks for an original project for these open spaces;
- definition of new prototypes concerning new urban functions, the new morphological relations between fabrics and networks, and new locations for developments with special attention to the methods of joining the textures and networks. Special attention is also paid to the typological and typo-morphological integration (often analyzed in terms of contamination, hybridisation or graft) of the traditional and historic models of public/private spaces described in the textbooks;

- landscape features of large networked engineering structures, special attention being paid to the problems of perception and inhabitability in the reciprocal and separate settings of natural landscapes and technical environments.

### **Urban Projects and Policies**

The interrelation between physical and socio-economic planning practices is the basis of a research programme which involves urban planning, design, law, economics and history.

Aim of the Programme is the improvement of the technical and procedural understanding of urban policies and projects, and of more specialized planning methods and techniques, to build up more reliable urban experts' roles and profiles and a better quality and transparency of expert contributions to the decision processes.

The main goals are the following:

- a. to develop issues and design methods for urban policies and projects - with specific reference to finance, economic and technical dimensions of the urban production systems, and to the real estate market dynamics;
- b. to define conceptual frameworks which, even if through different languages and focuses, may be helpful to the urban experts for developing a successful interdisciplinary co-operation.

The Programme offers four research streams:

- urban project methods and techniques;
- urban policy and plan techniques and procedures;
- spatial features of social exclusion;
- mobility and land use.

### **Urban, Regional and Environmental Planning**

The Doctoral Programme aims at creating high skills on interpreting and intervening in urban and environmental development practices and plans, with special emphasis on local development and on the emerging issues in interpreting and intervening on site as articulated in local systems.

The leading issues are:

- planning procedures with special reference to those emerging from the debate and from innovation in national and international legislation;
- the relationship between urban and regional mobility, safety and quality of urban environment and public spaces;
- policies concerning infrastructure design, as envisaged in strategic agendas;
- the town planning project, the space and landscape layout and interactive action plans shared by many actors;
- the adoption of the environmental approach as reorganization of spatial planning.

## Virtual Prototypes and Real Products

The educational aims of the Programme involve issues both cultural and scientific. By undertaking a course which incorporates the full range of technical disciplines, graduates are invited to investigate all aspects of product development using innovative virtual modeling methods and techniques throughout concept and functional design, ergonomics design, and product-use phases.

Additional research will concern simulation and virtual testing methods and techniques. The Course is particularly focused on dynamics and evolution of integration, and the relationships between methodologies, prototyping and simulation techniques and processes of manufacturing and testing through the use of digital prototypes. Further information can be found at the web site [www.vprp.polimi.it](http://www.vprp.polimi.it)

## Water Engineering

The Programme offers technical/scientific curricula focusing on the design, planning and management of sustainable development strategies related to the interactions between human life and environment in all aspects involving water. Major aspects of the Programme include problems related to land and integrated soil-groundwater protection, assessment of contaminant fluxes across scales, analysis and prevention of hydrologic, hydrogeologic and hydraulic risk, understanding and monitoring the hydrosphere, with emphasis on management of the water resources, aquatic ecosystems and technological industrial networks involving water. As such, the contents of the Doctoral Programme address the needs of setting the knowledge basis for understanding the different processes, integrating methods and tools of observation, measure and modeling, and creating a bridge across science, technology and planning actions, in order to establish settings and operative rules for an integration of water and socio-economic policies. Students are actively involved in National and International research projects, in collaboration with Academic Institutions and/or private/public agencies.



Laboratory model of a river

# Interaction with the Industry and with other research bodies

Doctoral Programmes offered at the Politecnico di Milano have established, and strive at continuously increasing, different forms of partnerships with industry and with other stakeholders of the social and economic world. These co-operations include, among others, funding research on specific issues, fostering the technology transfer, helping former Doctoral students start their own entrepreneurial activity.

These co-operations offer the Doctoral student several opportunities:

- The doctoral courses are designed and reviewed considering the real needs of the industrial, economic and social world, where the Doctors are supposed to develop their career after completing the course. To this end, each Doctoral course has its own Advisory Board, which acts as a link with the non academic world.
- Availability of internships, possibility of using labs and other research facilities owned by industries, interaction with industrial expertise.
- Student's placement is made easier and more efficient by the fact that students have already established contacts with a number of enterprises during their Doctoral studies.
- Additional scholarships are made available on specific subjects thanks to external funding.
- High-tech spin-offs by former Doctoral students are made easier not only by the existing network of connections with the economic and industrial world, but also by the presence within the Politecnico di Milano of a Business & Innovation Centre.

# Application procedures and scholarships

Candidates can apply for admission if they hold a graduate university degree. Doctoral Programmes are open to all nationals, with no age limit. Admission is granted on a competitive basis. Foreign citizens, or applicants with dual nationality (Italian and not Italian) may choose between two possible admission procedures.

**Admission based on entry examination:** by choosing this procedure, foreign candidates follow the same admission path as Italian citizens, i.e. they take an entering examination (a written exam and a colloquium) in Italian or English language, upon the candidate's choice. Based on the ranking of the admitted candidates, a number of scholarships are awarded.

**Admission based on the candidate curriculum vitae:** foreign or dual nationality candidates may apply for a selection based on the assessment of their curriculum vitae (CV), letter of motivation and letters of presentation. This special procedure does not require the entry examination but does not provide access to the scholarships awarded through the entry examination. For some Doctoral Courses, a limited number of scholarships are specifically awarded to foreign candidates choosing the admission procedure based on CV.

## Scholarships

The gross amount of each scholarship is €11.813,54 per year (year 2004). The number of scholarships available for candidates choosing each of the two admission procedures is variable from year to year.

Prospective applicants are invited to visit the web site of the Doctoral School (<http://www.polimi.it/phd>) in order to obtain more information on available scholarships.

Other scholarships of the same amount (called "thematic") are funded by external bodies (enterprises, research centres, public administrations) to support research on specific topics.

These thematic scholarships are awarded among the candidates who declare their interest towards the sponsored issue ("theme"), by means of a specific oral examination which is held in conjunction with the candidates' examination for admittance.

Therefore, foreign candidates wishing to apply for a thematic scholarship should choose the admission procedure based on examination. Potential applicants interested in thematic scholarships may obtain updated information either on the Doctoral School web site or by contacting directly the Chairman of the Doctoral Programme(s) of their interest.

Students (with or without a scholarship) may find further financial assistance in the form of research and teaching assistantship.

Usually doctoral students participate in the research activities of the Departments and may help professors in teaching at graduate and undergraduate level. Students may obtain information on these opportunities by contacting the Chairman of the Doctoral Programme before proceeding to register.

### **Tuition Fee**

Students obtaining a scholarship are exempted from paying any tuition or registration fee. Foreign candidates shall provide on their own for any immigration documents. Candidates not obtaining a scholarship, but anyway holding a suitable position in the evaluation list, may enrol by paying a tuition and registration fee of € 1500 per year. This fee is not due by foreign students supported by a scholarship provided by the Italian Government.

### **Facilities**

The Doctoral Programmes provide all Doctoral students with resources for the development of their research activities (use of laboratories, study space, access to libraries, funds for attending conferences and for research trips etc.)

### **Deadlines for application**

The competitive examination notices are issued in July. Applications forms are made available on the Doctoral School web site immediately after the publication of the notice. Candidates are recommended not to send their application before the publication of the notice. Deadline for submitting the application for admission is on mid September. Entering examinations and CV evaluations are completed before the end of November, and courses start on January. Contacts with the Chairmen of the Doctoral programmes may be established at any time during the year.

### **Accommodation and other facilities**

There is a limited availability of rooms specifically dedicated to foreign PhD students at the student dorms. Candidates who are interested in this opportunity must contact the Chairman of their PhD Programme as soon as they are informed upon their acceptance.

Other accommodation opportunities are provided by apartments that may be rented near the University campuses. The cost for accommodation in a rented apartment ranges from € 300 to € 800, depending on the location in the city, the apartment size and the number of people sharing the apartment.

The university and the students' associations support foreign students in finding an appropriate accommodation.

There are several university canteens in the Politecnico di Milano campuses. They offer complete hot meals for a cost ranging from € 2,75 to € 8,00 and are opened from Monday to Friday at lunch and at dinner time. In addition, there are several bars, pubs and restaurants.

Sport centres (gym, track and field, swimming pool) and other leisure facilities are available near the Politecnico di Milano Campuses and offer special conditions for students.



### **Italian Language Courses**

Italian language intensive courses are organized for incoming students free of charge. Language courses are offered at Leonardo and Bovisa campuses and are planned twice per year: from October to December and from March to June. The levels offered are: beginners, intermediate and advanced.

Classes are about 40/60 hours per course (twice or three times a week, late afternoon).

For information about Italian language courses: [italian-courses@polimi.it](mailto:italian-courses@polimi.it)

### **English Language Courses**

Although knowledge of English is mandatory for accessing PhD courses, advanced English Language Courses are offered to students at particular conditions.