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Uvodni referat

## **PRESENTATION OF PHD EDUCATIONAL PROGRAM AT THE POLITECNICO DI TORINO, WITHIN THE BOLOGNA AGREEMENT PERSPECTIVE AND WITH PARTICULAR INTEREST TO THE DEPARTMENT OF MECHANICS**

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**Summary:** *A doctorate research program at Politecnico di Torino is a three-year course, aiming at giving a high level of specialization and the methodological instruments to PhD students. The program is developed according to the reform of Italian University System, implementing the decisions taken by EU Ministers in Bologna in 1998. This paper is presenting the general information about doctorate course at above mentioned university, admission procedure, entrance examination, obligations of doctorate students and possibilities to get scholarship and European Doctorate. The structure of PhD studies at the Department of Mechanics with main educational goals, course curricula, leading of PhD students by tutors, research activities, projects and groups are also described. Finally a brief review of laboratories which are used by PhD students in daily research activities in order to complete their dissertation is given.*

**Key words:** *PhD studies, Politecnico di Torino, research activities.*

## **PRIKAZ OBRAZOVNOG PROGRAMA DOKTORSKIH STUDIJA NA POLITEHNICI U TORINU, BAZIRANIH NA BOLONJSKOJ DEKLARACIJI, SA POSEBNIM OSVRTOM NA DEPARTMAN ZA MAŠINSTVO**

**Rezime:** *Doktorske studije na Politehničkom fakultetu iz Torina odvijaju se u okviru trogodišnjeg kursa, koji ima cilj da pruži visok nivo specijalizacije i istraživačkog razvoja doktorantima. Program je razvijen na osnovu reforme Italijanskog Univerzitetskog sistema, koja primenjuje odluke usvojene od strane ministare Evropske Unije u Bolonji 1998. godine. Ovaj rad predstavlja osnovne informacije o doktorskim studijama prethodno navedenog univerziteta, opisujući kompletnu proceduru upisa, prijemnog ispita, obaveza doktoranata, kao i mogućnosti dobijanja stipendije i Evropske doktorske titule. Objasnjena je i organizaciona struktura doktorski studija na Departmanu za mašinstvo sa glavnim obrazovnim ciljevima, oblastima rada, saradnja doktoranta i mentora, istraživačke aktivnosti koje studenti doktorskih studija obavljaju, kratak pregled projekata i naučno*

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*istraživačkih timova. Takođe, predstavljen je i kratak opis laboratorija*

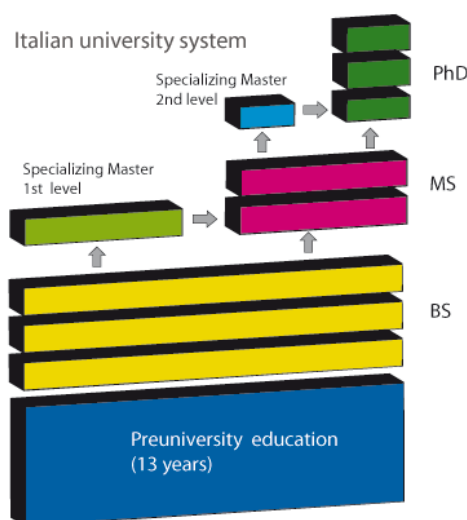
**Ključne reči:** doktorske studije, Politehnički fakultet iz Torina, istraživačke aktivnosti

## 1. INTRODUCTION

The Politecnico di Torino is the one of the most prestigious institutes in technical and scientific field in Italy; it is located in Turin, the capital of Piedmont Region. Thanks to its geographical location, the Politecnico is at the center of the principal industrial European systems and it is very important factor for industrial, technological and social modernization. The year 2009 is marked as the 150th anniversary of Politecnico di Torino foundation and its long-standing tradition has been the basis for the reputation it enjoys today as one of the leading technical universities in Europe and throughout the world. In fact according to the Jiao Tong University's league table, it holds the 7<sup>th</sup> place in Europe for engineering studies, and is first in Italy for internationalization and for technical studies according to league tables compiled by Vision and Censis.

In order to organize and manage its didactic activities, the Politecnico has 5 Faculties (3 of Engineering and 2 of Architecture) and the Scuola di Dottorato (PhD School). There are 18 Departments that manage one or more research fields, promote and coordinate research activities and organize research activities for external bodies. There are about 28000 students enrolled every year, of which about 3500 are new enrollments. Students are studying mainly in the Torino campuses but also in other 5 campuses, located all over the Piedmont. About 700 are PhD students, more than 240 new PhD students every year.

The main educational activities are coordinated according to the reform of Italian University System. This reform has introduced some important innovations in the organization of the academic degrees, implementing the decisions taken by EU Ministers in Bologna in 1998. The new system can be illustrated as follows:



**Figure 1:** Italian university system

- ❑ The first cycle (Laurea) has 3-year duration for a total of 180 ECTS. It leads to a Bachelor of Science equivalent degree (UK);
- ❑ The second cycle (Laurea Specialistica or Laurea Magistrale) has 2-year duration for a total of 120 ECTS. It leads to a Master of Science equivalent degree (UK);
- ❑ The third cycle (Dottorato) has 3-year duration for a total of 180 ECTS. It leads to a PhD equivalent degree;
- ❑ After the first cycle, the Italian system provides a 1-year course (minimum of 60 ECTS) leading to a 1<sup>st</sup> level Specializing Master;
- ❑ After the second cycle, the Italian system provides a 1-year course (minimum of 60 ECTS) leading to a 2<sup>nd</sup> level Specializing Master.

The university reform has introduced the system of university credits (ECTS) for the first time in Italy. The principal objectives have been to make studies more conscious of the student effort, to reduce the gap between the official and real length of courses as well as to lower the drop-out rate. The main characteristics of the system are as follows:

- ❑ The credits represent the student's total workload (class time, individual study, exam preparation, practical work etc.) and one credit is equivalent to 25 hours. The average full-time workload for one academic year is 60 credits which is equivalent to 1500 hours. Universities may opt for an increase or decrease in this total workload of a maximum 20% (1200-1800 hours), but they must justify this change.
- ❑ The amount of time reserved for individual learning or other individual educational and training activities must not be lower than 50%, except for the courses that include practical or laboratory work.
- ❑ Credits are earned once the student has passed the assessment for each course or activity.
- ❑ The total or partial recognition of credits obtained by students wishing to continue their studies in a different degree programme or different institution is at the discretion of the educational authority, in accordance with the criteria and procedures of the university teaching regulations.
- ❑ The teaching regulations of each university can provide for regular reassessment of credit allocation and indicate the minimum number of credits that must be achieved within a fixed period of time (in the case of full or part-time studies).
- ❑ Universities can give credits for professional skills and experience, according to the regulations, as well as other skills and knowledge acquired in post-secondary level courses that have been set up and taught in collaboration with the university.

## **2. DOCTORATE STUDIES AT DEPARTMENT OF MECHANICS AT POLITECNICO DI TORINO**

Doctorate studies at Politecnico di Torino are completely organized by PhD school (Scuola di Dottorato) and divided into 4 main discipline areas: Civil engineering and architecture area, Information and communication technology area, Industrial engineering area and Base science area that includes Physics, Chemistry and Mathematics. All these discipline areas consist of 18 particular doctorate courses such as mechanical engineering, electronic engineering, energetic engineering, aerospace engineering etc. A PhD lasts three academic years and at the end the candidate is appointed with the title of Doctor of Research.

The Department of Mechanics (DIMEC) promotes and develops its educational and research activities in the traditional fields of mechanics, such as automotive and railway

engineering, robotics and industrial machinery of different kinds as well as in edge topics such as biomedical and aerospace applications, new materials and micro-nanotechnologies. Furthermore, it is concerned about the basic research on the related methodological aspects.

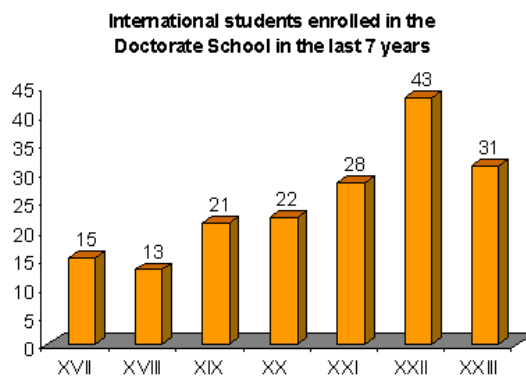
The strong relationship with the automotive and aerospace sectors, that is also a consequence of its geographical position, are the result of a deeply-rooted and multicultural tradition, which has been capable of exporting its knowledge and skills in seeking and proposing advanced solutions in several industrial fields. Research is oriented both to the solution of practical problems and to the correct definition of basic theoretical aspects.

Doctorate programs at Department of Mechanics are organized in following three disciplines:

- Mechanics
- Mechatronics
- Biomedical Engineering

**The educational goal** of the PhD program in Mechanics is to train professionals able to cope with the analysis, functional and structural design and control of devices and complex mechanical systems through the development of theoretical and experimental activities in the research sectors of the mechanics. Training is oriented towards both academic and industrial openings with particular attention toward research and development activities for innovative products and processes.

**The procedure for admission and the equivalence evaluation of the university diploma** earned by foreign country applicants are first important requirements that students have to fulfill. Participation in the competitive examination for admission to the Doctorate courses at Department of Mechanics is open to candidates who are in possession of the Italian “laurea magistrale” or of an equivalent master of science-level degree obtained from a foreign university. The number of foreign PhD students at Politecnico di Torino and at Department of Mechanics is significant. On the following figure we can see the number of international students enrolled in PhD school in the last seven years.



**Figure 2:** Number of international students enrolled in doctorate studies at the Politecnico

Candidates, who have obtained a Master's Degree abroad and have a Rector's decree of declaration of degree equivalence issued by an Italian university, have to send this document to the Doctorate School of the Politecnico di Torino at application.

Candidates who have obtained a master of science degree abroad, which has not yet been declared equivalent from an Italian university, have to send the programs of all taken and passed exams at their home university at application.

Other important documents that applicants have to pass through are: CV, copy of Bachelor and Master of Science degrees with relevant scores of exams and final grades, abstract of Master of Science thesis, short report on scientific interests and reasons for applying, short research project proposal, documentary evidence of competence in English (or Italian) language, recommendation letters (maximum 2) written by professors of Italian or foreign universities and any other document that may be useful to support the application (awards, professional activities, publications, etc.).

**The entrance examination to the doctorate course** at the Politecnico di Torino consists of the evaluation of the candidate's educational and scientific background and of his research project proposal. Each year there is a limited number of applications accepted for the Doctorate School, these are subdivided into two groups: one of regular positions reserved to students with scholarship (about 40% of the total), and a number of supernumerary positions (without scholarship) divided between departments and reserved to:

- EU and non-EU citizens with a scholarship subsidized by their home university, Government or national and international public institutions
- Non-EU citizens in the framework of international agreements activated by the Politecnico di Torino.

At the discretion of Academic Board of each Doctorate course, the oral test could include an evaluation of the applicant's knowledge of one or more foreign languages.

For the assessment of applications, the Boards of Examiners have 100 points that will be distributed – at their discretion – among the categories Education, Research and Additional Qualifications, as detailed below:

#### **Education**

- Final score of both Bachelor's and Master's degrees, together with transcripts of all taken exams and obtained marks, during both the Bachelor's and the Master's degree programs;
- Abstract of Master's degree thesis;
- Any other educational qualification obtained by the applicant.

#### **Research**

- Report in which the applicant details scientific interests and motivations for applying;
- Research project proposal on one of the thematic subjects the existing research groups of the chosen Doctorate Course are focusing on, or alternatively, on the research themes of the IIT (Italian Institute of Technology) Project;
- Any publication or scientific qualification obtained by the applicant.

#### **Additional Qualifications (not compulsory)**

- TOEFL, IELTS, PET (or equivalents) with a score equivalent or higher than those requested to apply for the Doctorate;
- GRE (General Test or Subject Test related to the chosen Doctorate), GMAT test scores or equivalents;
- Awards;

- ❑ Professional experience;
- ❑ Recommendation letters by professors, scientists or researchers of either Italian or foreign institutions;
- ❑ Any other qualification that the applicant considers a possible support to his/her application.

**A special Board of Examiners for the applicant's evaluation and for the admission decision** is appointed for each of the different doctorate courses. It is staffed by three members, chosen among the full-time faculty members in the relevant area of study. Board members can be flanked by up to two experts of clear repute, whether Italian or foreign, from public and private universities and research organizations.

**As a result of the evaluation procedure** the Board of Examiners draws up the ranking on the basis of the comparative evaluation of the candidates. Candidates shall be admitted to the chosen Doctorate on the basis of their standing until all the available positions, with and without scholarship, have been filled. **The scholarships** are awarded according to the ranking, based on the comparative evaluation by the Boards of Examiners. Eventually not reserved positions still available at the end of enrolment on account of their not having been awarded, can be redistributed without scholarship among foreign candidates selected on the basis of submitted titles and their place in the final ranking.

**Educational and research activities and course curricula** are presenting the bases of the doctoral training of candidates. Every PhD student is under an obligation to attend the Doctorate program throughout the established three-year period and to acquire 180 credits in total (60 per academic year). An educational plan is defined for each student with the minimal value of 45 credits, usually obtained attending mainly third level (PhD) courses but also some second (Master of Science) level courses. Moreover, credits can be obtained attending courses or seminars or carrying out activities research in other Universities or Institutes, in Italy and abroad. During the three-year period, each student will perform an original research activity in the chosen curricular area with the assistance of a tutor. Such activity involves a share of the total undertaking varying from 60% to 75%.

The main PhD research areas at Department of Mechanics are:

- ❑ Dynamics and control of mechanical systems;
- ❑ Micromechanical devices and Microsystems;
- ❑ Automated machinery and robotics;
- ❑ Fluid mechanical systems;
- ❑ Tribology;
- ❑ Vibroacoustic;
- ❑ Theoretical-experimental analysis methods for mechanical design;
- ❑ Mechanical machine, structure and system modelling methods;
- ❑ Behaviour of materials for mechanical structures;
- ❑ Non destructive diagnostics and testing methods;
- ❑ Design and construction of vehicles, machineries and systems.

Training can also include active learning activities, taking part in teaching support activities in the fields of Applied Mechanics and Machine Design and Construction. Students are also encouraged to participate to national and international conferences.

In order to obtain the title of Doctor of Research the knowledge of the English language is required. This knowledge, entailing the acquisition of 5 specific credits, must be certified

either by the IELTS Certificate with scores 5.0 or by PET certificate with at least pass with merit evaluation or by other equivalent, or higher, certificates. Foreign students must include in their curriculum an Italian language course or submit a certificate attesting their knowledge of the Italian language, released by the Linguistic Centre of the Politecnico.

**Research projects at the Department of Mechanics** are covering wide number of disciplines. PhD students become members of research groups which are working on a lot of industrial and university projects. So the projects, in which students are involved at the Department of Mechanics, whether oriented towards solving application problems or dealing with theoretical aspects and basic methods, addresses the following areas:

**Design of mechanical systems and components:** Reliability, fatigue of materials and mechanical structures, test methods and experimental mechanics, functional and structural design, rotor dynamic, noise and vibration, active vibration control, tribology.

**Design of automated mechanical, robotic and mechatronic systems:** Fluid automation, control of mechanical systems, magnetic bearings, mechanical microsystems, servosystems, automated space systems, hydraulic and pneumatic systems, robotics.

**Ground vehicle design:** Reliability, comfort and vehicle dynamics, stability, functional and structural design, safety, structures and body shells, powertrain, servosystems.

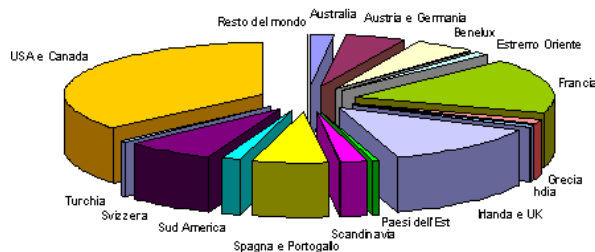
**Industrial bioengineering:** Orthopedic and dental biomechanics, cardiocirculatory biomechanics, cellular mechanics, biomolecular mechanics, tissue engineering,

At the end of each academic year, doctorate students submit to the Academic Board a detailed report on the performed educational and research activities. Based on the evaluation of the credits acquired by the student and of the quality of his research activity, the Academic Board decides the admission to the following year or to the final examination, depending on whether the student is a first, second or third year student. A negative evaluation of the Academic Board - at the end or during the academic year - entails the loss of the right to participate in the Doctorate courses and the obligation to refund the received scholarship grant, if any, for the current year.

Third year doctorate students are entitled to take the final examination only if they have acquired all the specified credits. Otherwise, the Academic Board can grant a one-year extension, without scholarship.

A doctorate student may attend training or theoretical courses at other universities, research institutes, centers and laboratories, in Italy and abroad. In the following figure we can see the mobility of PhD students and the countries with which Politecnico di Torino has student exchange projects and collaboration activities.

Each doctorate student is allowed to spend from six to up eighteen months abroad during his three year PhD courses and is encouraged to spend at least six months.



*Figure 3: Mobility of PhD students*

**The procedure for the attainment of the title of Research Doctor** is explained in following. Admission to the final exam is allowed to third year students having all the necessary qualifications required in the regulations, particularly:

- 180 credits distributed as envisaged by the plan of studies, the 5 specific credits for the knowledge of English compulsorily included;
- A positive evaluation of the dissertation from the Academic Board.

The final evaluation prior to the granting of the Title is entrusted to a special Board of Examiners staffed by three members, selected from among the full-time faculty members and researchers and specifically qualified in the relative reference sectors. At least two members must serve on the faculty of Italian or foreign universities not involved in that particular Doctorate. The Board of Examiners can be flanked by up to two experts of clear repute, belonging to university institutions or public and private, national or foreign, research organizations. In the event of co-directed thesis agreements or international joint doctorates, the Board is staffed according to those agreements.

The Title of 'Doctor of Research' is obtained by passing the final examination, which can be taken only twice. Generally the final dissertation is written in English.

**The European Doctorate** is an award of an individual European university, made in accordance with the criteria set out by the Confederation of European Union Rectors' Conferences, it will be conferred if the following conditions have been met:

- Favorable reports must be produced by at least two professors from two universities in two separate European countries other than Italy,
- At least one member of Committee must be from a higher education institution in a European country other than Italy,
- The Presentation of the Doctoral Thesis must be partly made in the official language of an European country, other than Italian,
- Doctorate student must have spent at least 3 months in another European country as part of the preparation stage of their Doctoral Thesis.

**The work in laboratories** is very important part of PhD education, and it is nearly impossible to get the PhD degree without the presentation of concrete results got in laboratory environment. Department of Mechanics Laboratories are widespread in several campuses in the Piedmont region, where labs are established not only for educational activities but also for research activities. The Department of Mechanics is currently implementing a **UNI EN ISO 9001** quality system for its laboratories to ensure that all processes are carried out according to uniform, consistent and controlled procedures



complying with the reference standards. The laboratory mission is to provide faculty members and researchers with the personnel, test rigs, machinery, instruments and equipments needed for research, teaching, thesis work and third-party testing. One of the most modern labs of the Department of Mechanics is situated in the Vercelli campus and here we will illustrate its main equipments and test machines. The **Reliability and Safety Laboratory** contains experimental equipments for testing materials and structures. Besides the standard equipment (one electromechanical universal testing machine and one hydraulic universal testing machine) it has machines for impact and high strain-rate testing (Hopkinson bar, drop tower, medium speed loading apparatus), for non-standard testing (hydrostatic, combined loading, bending, torsion, shear loading...) and fatigue (rotating bending, strain controlled fatigue loading). It is also possible to perform strain measurements by means of extensometers, strain gages and other techniques, and dynamic measurements by means of various data acquisition systems and different transducers (for load, displacement, acceleration...).



*Figure 4: Hopkinson bar and drop tower situated in Vercelli*

### 3. CONCLUSIONS

The PhD activity at Department of Mechanics of the Politecnico di Torino is addressed to students whose main interest is the high level research and it aims at preparing them to be employed at Universities, public corporations and private enterprises equipped with research departments and institutes.

The world wide recognised diploma is giving very good opportunity for jobs also outside of Italy. One of the very important aspects of PhD studies is the contact and cooperation possibilities with companies (on a national and/or international basis) during the development of projects. This is also evidencing leadership and stimulating organizational characteristics of the future Doctors, as this cooperation is mainly based on team work.

The main aim of the PhD course is to develop professional figures that are trained in basic and applied research oriented to academic but also to industrial world (the latter devoted to innovation of products and production processes), that are also able to work in highly interdisciplinary context and in the field of the most innovative technologies, and that will be part of a new management, sensitive and attentive to research goals and issues.

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