

**DOCTORAL STUDY PROGRAMS AT ITALIAN POLYTECHNIC  
INSTITUTES  
Eshkabilov S. L.**

*This paper presents brief overviews, summary points and recommendations from the seminar-discussion facilitated by professor Genta from Politecnico di Torino, Italy in the example of Italian Technical Universities.*

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DASTURLARI  
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*Ushbu maqolada Italiya texnika oliy gohlarida doktorantura dasturlariga bag'ishlangan seminar hulosalari va bir qator tavsiyalari yoritilgan. Bu seminar Turin Politehnika Instituti professori Genta tomonidan olib borildi.*

**УЧЕБНЫЕ ПРОГРАММЫ ДОКТОРАНТУРЫ В ИТАЛЬЯНСКОМ  
ПОЛИТЕХНИЧЕСКОМ ИНСТИТУТЕ  
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*В статье освещаются вопросы подготовки докторантов в итальянском политехническом институте и соответствующие учебные программы по материалам совместного семинара с Туринским политехническим институтом.*

A seminar-round table discussion on Doctoral study programs in Italian Polytechnic Universities was hosted at Tashkent Automobile Road Institute, on August 27, 28 and 29. Seminar was facilitated by professor Giancarlo Genta from Turin Polytechnic Institute. In the seminar, over 50 researchers, professors and administrative staffs from 21 Uzbek higher educational institutions and research institutes of Academy Science of Uzbekistan have actively participated. The seminar is carried out within the framework of the Tempus programme of the European Commission and is arranged with the support of UNICA association, EU Delegation to Uzbekistan, National Tempus Office, and Ministry of Higher and Secondary Specialized Education of Uzbekistan. The seminar will be facilitated by Professor Giancarlo Genta, Department of Mechanical and Aerospace Engineering, Politecnico di Torino, Torino, Italy. Professor Giancarlo Genta is a full member of International Academy of Astronautics and Academy Science of Torino, president of Ce.I.D.A- Automotive Engineering university Center, coordinator of PhD program in Mechatronics at Politecnico di Torino, a reviewer of over two dozens of internationally renowned scientific journals including IEEE/ASME, automobile engineering and robotics.

The seminar topics have covered key issues such as: General Admission Requirements of Doctoral School at Italian Polytechnic Institutes, Doctoral School and study programs at Politecnico di Torino, Doctoral Study Courses and

Research Projects of Doctoral Students at Politecnico di Torino, Publications: What to Publish, How to Publish, Doctoral Defense Procedures at Italian Polytechnic Institutes. Besides, during the seminar there have been questions and hot discussions regarding undergraduate and graduate studies, university rating systems and university – industry links.

Briefly, the following points can be summarized from the seminar discussions. First, the seminar participants have gained substantial amount of decent information on three-cycle system at Italian universities in general and legal issues in awarding Bachelor (BSc), Master (MSc) and PhD degrees starting from 1999 according to the Bologna Agreement. In Italian universities, there are post-graduate study programs which include Master courses but nothing to do with Master's programs and are taught in parallel with Master or PhD studies.

PhD studies last exactly for three years and all technical details of PhD studies are defined by a law and structure of PhD studies are the same for all universities of Italy. At mean time, first two cycle study degrees have a legal value in Italian university system, but a PhD degree does not have a legal value. The reason for not that is it is very difficult to obtain a researcher position in Italian universities at mean time. Thus, now more and more focus in PhD study programs is directed towards jobs in industry and public administration not in university-academia. In this case, some general statistics is given that less than 8% of PhD graduates after acquiring Doctorate degree will remain at universities in Italy. This issue is explained with a trend of aging population and decreasing number of students at Italian universities. Even though PhD study programs and degree requirements are well defined and respected for certain extent, Italian industries are not yet fully used to the three-cycle degree system and require and tend to hire mostly engineers with Master's degree that is equivalent of the old 5 years of education. Similarly, BSc degree holders also can't find jobs easily and thus, they pursue MSc degree in most of the cases that is about 90% of BSc holders.

PhD admission requirements at Italian universities are relatively simple. All applications are processed via on-line application platform; for instance, at Politecnico di Torino applications are submitted via a website: [www.polito.it](http://www.polito.it). PhD courses start in October (In Torino recently they started in January, but starting from 2014 they will start in October). The deadline for applications is fixed by the University (usually this is around the end of September). Students ending Master studies within December can apply, but the application is invalid if they do not comply.

The general requirements are students must have a MSc degree (or equivalent). Even if they have a MSc degree, candidates who have not a full 18 years of school (primary, secondary and University) are not eligible. The selection criteria are defined by each University. In Politecnico di Torino there is a board that pre-examines the applications to check that they are eligible following the general criteria. Each course has a selection commission that evaluates the curricula and publications of candidates, their specific background, their knowledge of English language. A colloquium or an interview with the candidates

is usually required. If there is a candidate from abroad, then interviews are arranged via skype. The above selection criteria cannot be applied too strictly: for instance an old candidate with many publications is not necessarily preferred to a younger candidate with fewer publications. The commission makes a priority list. The candidates chose the scholarship following the position in the list. The last ones get places without scholarship.

Scholarships for PhD students. Students enrolled in PhD courses may or may not have scholarship. There are a few scholarships available for PhD students at Italian universities. Scholarships may come from

- university (paid by the Ministry of education)
- directly Ministry of education
- public administration
- private companies

The amount of the Scholarship is 1032 €. In some cases the scholarship may be increased if the student works on a contract. A company that offers a scholarship must guarantee that the scholarship covers all 3 years. University scholarships are 'generic' while scholarships from the ministry, companies etc. are linked to a specific research theme. In case a company does not guarantee the 3 years (and cannot supply a scholarship) it can make a research contract with a Department, that can pay a 'student without a scholarship' on a monthly base. The total number of places available for each PhD program cannot be more than twice the number of scholarships and is limited due to available facilities (lab space, equipment, etc).

## **2. Doctoral School and study programs at Politecnico di Torino**

**PhD School:** Politecnico di Torino has a PhD school to coordinate all PhD courses (SCUDO). There are PhD courses focused on 4 different areas: 1) Civil Engineering and Architecture, 2) Information and Communication Engineering, 3) Industrial Engineering, 4) Physical, Chemical and Mathematical Sciences for Engineering.

Subsequently, **PhD program in Civil Engineering and Architecture** are subdivided into: 1) Architecture and Building Design, 2) Cultural Heritage, 3) Engineering for Natural and Built Environment, 4) Environment and Territory, 5) History of Architecture and Town Planning, 6) Structural Engineering, 7) Technological Innovation for Built Environment, 8) Water and Territory Management Engineering.

**PhD program in Information and Communication Engineering** are subdivided into: 1) Computer and Control Engineering, 2) Electronic Devices, 3) Electronics and Communications Engineering.

**PhD program in Industrial Engineering** are composed of: 1) Aerospace Engineering, 2) Biomedical Engineering, 3) Chemical Engineering, 4) Electrical Engineering, 5) Energetics, 6) Mechanics, 7) Mechatronics, 8) Production Systems

& Industrial Design.

**PhD program in Physical, Chemical and Mathematical Sciences for**

**Engineering** are subdivided into: 1) Fluid dynamics, 2) Materials Science and Technology, 3) Mathematics for Engineering Sciences, 4) Metrology: Measuring Science and Technique, 5) Physics.

Each PhD program has a council made of at least 10 professors (now increased up to 16 by the new regulations. At least 12 must be full or associate professors, 4 may be researchers). The council elects one of its members to be the coordinator. The coordinator is in office for 4 years, and can be re-elected once. A professor cannot belong to two councils at the same time. Many programs offer several curricula. The 24 PhD programs are going to be reduced to 12 -14 courses owing to a change in the law (note that there is no PhD program in Automotive Engineering: most courses in Industrial and Information Engineering offer research in Automotive Engineering). These changes will be implemented starting from this year.

**Research and study.** The basic idea under the PhD courses is learning to do research by doing research: the stress is thus laid on the research activity of the student. However, it is compulsory that the student follows a number of subjects in the 3 years. The amount of credits depends on the course, and is usually between 45 and 50 (PhD program in mechatronics requires 45 credits).

**Subjects**

Each year the PhD School of Politecnico publishes a catalog of subjects (Third-level courses). Each student has a tutor, who also acts as supervisor of his thesis. Students chose a professor to be their tutor when they enrolled at the first year. The tutor may also be also from outside of the Council of the PhD program.

Each student can choose freely (in agreement with his tutor) among the courses of the catalog suggested for his PhD program. Other third-level courses can be chosen, but must be approved by the council. Students can chose, usually under suggestion of their tutors, First- (BA) or Second- (MA) level subjects, usually for no more than 1/3 of the total number of credits. This choice must be approved by the council. Other activities, for instance, participation in courses at other Universities, participation in conferences or seminars etc., can be used by students to obtain credits, but this must be approved by the tutor and then by the Council of the program and finally must be ratified by the coordinator. At the beginning of each year the council approves the plan for the year of each student. At the end of the year any change must be approved.

**Importance of the Thesis.** The thesis is an important part of the work of a PhD student, but his/her research work may be not entirely focused on it. As already stated, the main activity of a PhD student is doing research, but it is not said that all this work is on a single subject and contributes as a whole to the thesis

A first possibility is working for 3 years on a single subject and then summarizing the whole thing in the thesis. A student may work on different areas, even on different projects, and then focus his/her activity of the third year on the thesis.

*A personal suggestion from professor Genta:*

*Even PhD studies should not be too specialized and working on different projects is encouraged.*

*The activity of a student should involve analytical, numerical and experimental aspects.*

**Experience abroad.** Students are encouraged to spend some time in a foreign university or research center.

In some PhD courses a minimum period abroad is compulsory. When the students are abroad, the scholarship is increased by a fixed amount. If the activity abroad involves also the thesis, a foreign professor may be a co-tutor. Some difficulties can be encountered when the scholarship is paid by a company. In case of multinational companies the period abroad may be spent in a foreign research center of the company, or in a University with which the Company has cooperation agreements.

**PhD Council of the School.** The council of the school is made by the coordinators of all courses, plus a number of Professors designed by the Rector. The Council of the school elects the director of the School. The coordinators of the courses of each area elect the one of them to be the representative of the area.

The four Representatives of the areas plus the Director constitute the board of the School. The Council of the school discusses all matters related to the school, but important decisions must be approved by the Rector, the Senate or the Administration board, following their competences. The Board of the school decides on many practical matters, like the catalog of the third-level courses, the invitation of external, mainly foreign, professors to give courses, etc.

### **3. Doctoral Study Courses and Research Projects of Doctoral Students at Politecnico di Torino**

**Example: PhD program in Mechatronics.** The goal is training professionals in possession of specialist knowledge and having appreciable interdisciplinary capabilities, who are able to interact with specialists from the various areas in order to make significant contributions at system level. The students work on research projects in teams including students (also MA students working on their Master thesis) with different background. The first year is basically devoted to supplying a common background (e.g., Electronics and Computer Science for students coming from a MA in Mechanics). The following years are devoted to research in multidisciplinary teams. Specific labs: Mechatronics Lab (LIM), now belonging to the Department of Mechanical and Aerospace Engineering in Torino main Campus and in Verrès Campus (total 30 places).

#### **Involved professors:**

Coordinator Giancarlo Genta (specialization area: aeronautics and mechanics). Nicola Amati (specialization: mechanics); Basilio Bona (specialization: computer science & Control); Aldo Canova (specialization: Electronics & Electrical Eng.); Stefano Carabelli (specialization: computer science & Control); Marcello Chiaberge (specialization: Electronics & Electrical Eng.); Dante Del Corso;

Giovanni Griva; Franco Maddaleno; Maurizio Rebaudengo; Andrea Tonoli (specialization area: Mechanics). Specialization areas of professors in PhD program of Mechatronics are interdisciplinary.

**Research areas and topics in PhD program of Mechatronics.**

Design and construction of complex electromechanical systems: Mechatronic automotive systems; Mobile and service robotics; Digital platforms for the control of mechatronic systems. Design and construction of complex electromechanical systems areas: Magnetic suspension systems; Piezoelectric transducers; Electromagnetic dampers; Dynamics of controlled rotors; Electrohydrostatic transmissions. Mechatronic automotive systems: Combustion and vibration control in internal combustion engines; Light hybrid vehicles. Mobile and service robotics: Locomotion and transmission systems; Navigation systems and sensors; Electronic on-board systems; Digital platforms for the control of mechatronic systems. Magnetic suspension systems: Magnetic suspensions for rotating machines: active and passive (mostly electrodynamic) magnetic bearings; Magnetic levitation (MAGLEV) vehicles; Vibration insulation systems based on Maxwell and Lorentz actuators. These studies include also the dynamics of the mechanical subsystem, the power and control electronics, sensors and control algorithms.

Piezoelectric transducers. The research is focused on piezoelectric sensors and actuators working in self-sensing mode and topics cover: Mathematical modeling; Experimental validation; Development of test benches, provided with power and signal electronics completely developed in the Mechatronics lab; Development of piezoelectric devices for industrial applications.

Electromagnetic dampers. The research is focused on the development of electromechanic vibration dampers, of the active and passive (motional and reluctance) type. The integrated design approach allows these systems to be competitive with respect to the conventional systems. The following topics are in this domain: Torsional vibration dampers; Automotive shock absorbers; Damped landing legs for space probes.

Dynamics of controlled rotors. The research is focused on active and semiactive systems for vibration control in rotating machines, in particular aircraft engines. Various types of electromagnetic actuators, control systems and algorithms have been studied. Test rigs have been built for the validation of the mathematical models built.

Electrohydrostatic transmissions. The research is focused on developing electrohydrostatic systems, both for linear and rotary actuators. Force or velocity control is easy as with electric actuators, while the very high transmission ratios supply high forces and torques.

Combustion and vibration control in internal combustion engines. The first topic is basically centered on the realization of piezoelectric injectors for diesel engines, and of the related control devices. The second topic deals with the realization of electromagnetic torsional vibration dampers for internal combustion engines (mainly large truck diesel engines).

Light hybrid vehicles. Study of small urban vehicles with low fuel consumption and good comfort and safety. The following topics are covered under this domain: Conventional configuration (4-wheels); Unconventional configuration (3-wheels, tilting body); Different control and power architectures; Development of ad-hoc electrical machines.

Locomotion and transmission systems. This area is focused on mobile and service robotics, and covers the following topics: Walking robots; Wheeled robots; Innovative elastic wheels for planetary rovers; Suspension systems for robots (passive and active); Transmission systems for robots (in particular, electrohydrostatic).

Navigation systems and sensors. This area deals with mobile and service robotics and covers: Navigation algorithms and systems for mobile robots, possibly with articulated arms; Machine vision; Sensor fusion.

Application areas are: Space exploration; Security; Environment monitoring; Rescue.

Electronic on-board systems. This domain is also for mobile and service robotics and has topics in: Embedded platform for the elaboration of navigation and sensing algorithms; Modular to supply resources also to on-board payloads; Based on libraries supplied by ESA, NASA and ASI; Using read-hard components; Granting low energy consumption. The system architecture must be highly reliable and redundant.

Digital platforms for the control of mechatronic systems. The control boards used in the various mechatronic applications are developed in the mechatronics lab. Such devices must be flexible to allow an easy use in the various applications and in different sectors (industrial, automotive, robotics and space), operate in real time and have a high number of I/O.

### **Main collaborations of the Mechatronics Lab**

#### ***Universities:***

Ecole Polytechnique Fédérale de Lausanne (EPFL) – Switzerland; Technische Universität München, Munich, Germany; Livingston University, London, England.

#### ***Companies:***

FIAT Research Center; AVIO spa; Thales Alenia Space; Alenia spa; Nuovo Pignone – General Electrics; SKF Industrie spa; General Motors Powertrain Europe srl; Exagon srl; Carlo Gavazzi Space; OSAI A.S. srl; Consorzio Intellimech; AMET S.r.l.; Compagnie Valdôtaine des Eaux S.p.A.; Negasat snc; ALTAIR ENGINEERING S.R.L.; Fasti spa; TECHNOGYM S.R.L.; Dayco Europe; Ecomacchine spa; Pinto srl; Savio spa; Landi Renzo spa; Itec Tecnologie ed Impianti spa.

### **Some specific Courses within PhD program in Mechatronics**

Analysis and Design of Electromagnetic Devices by Numerical Methods; Geometric and probabilistic Fundamentals in Robotics; Complementi di modellistica e simulazione di sistemi mecatronici

Rotordynamics; Dynamics of motorcycles and tilting tricycles; Control of

mechatronic systems.

#### **4. Publications: What to Publish, How to Publish**

**Initial rules of PhD in Italy.** The law that started PhD studies on Italy stated that the thesis must be original and stated that PhD students cannot publish anything related to it before. In the years this law was changed and the students are allowed to publish even things related to their thesis. Now PhD students **MUST** publish as much as possible during their career.

**Minimum number of publications.** Each course has its rules about the minimum number of publications, i.e., at the end of the first year: one publication (anywhere); At the end of the second year: one publication (anywhere) + one publication on ISI journal; At the end of the second year: two publications on ISI journals

**Non-disclosure agreements.** Students with industrial scholarships or working on industrial projects may be required to sign a non-disclosure agreement (N.D.A.). In this case, the decision about whether something may be published depends on the company. If a student does not meet the publication requirements due to N.D.A., an exception can be made and he can be admitted to the following year.

**Choice of the journal.** Usually the tutor can advise the student on the choice of the journal. In most cases the paper is published jointly by the tutor and the student. There are cases where the PhD student is a part of a research group, and the paper may have several authors. There is no restriction on the number of authors of the papers taken into account for the admission to the following year.

**Some key remarks and recommendations on number of publications.** Well known professor Stephen Harry Crandal from MIT stated on increasing number of research publications that nowadays noise is overcoming quality signal. That can be interpreted as the more publications does not mean higher the quality of research. An interesting study on publications is carried out recently in the USA. A few researchers in sociology collected random terms in sociology using internet search engines, and then from collected random terms and statements prepared a paper and published under a fake name. This paper has ended up being one of the most referenced and reviewed papers in the area despite its poor quality.

*Personal recommendation from Professor Genta on number of publications:* It is necessary for PhD students to publish but not too many that means more than 5-6 publications are too much. Also, it is strongly advised to publish in internationally renowned, respected and peer-reviewed scientific journals, for instance, in ISI (Institute of Scientific Information: [http://wokinfo.com/publisher\\_relations/journals](http://wokinfo.com/publisher_relations/journals)) journals.

#### **5. Doctoral Defense Procedures at Italian Polytechnic Institutes**

**Yearly exam.** At the end of the 1st and the 2nd year (usually in December) the candidates present and discuss their work of the year. The presentation is public and anybody can ask questions. Each student is allowed 10-15 minutes for the presentation plus time for the discussion. At the end of each discussion the Council



of the Course decides whether the student is allowed to proceed. A failure involves the end of the career of the student and of the scholarship. At the end of the 3rd the candidates present and discuss their work of the year, in the same way seen before for the students of the 1st and 2nd year. The council of the Course decides whether the student is allowed to proceed with the final exam. A failure may involve the end of the career of the student or the decision to proceed with a 4th year (an exception).

**PhD Exam.** The PhD students defend their thesis in front of a commission made by 3 professors, 2 of which must belong to a different University (Italian or Foreign) and one must belong to the Council of the specific program. The defense of all thesis of the course occurs in a single session every year. The course ends at the end of December and the defense exam is usually in February or March. For programs with widely varying subjects or with too many candidates, more exam sessions may be arranged in the year (always in February-March). The Council of the course selects 6 professors (2 from the Council and 4 from other Universities) and the School chooses 3 of them (1+2) by extraction as official members of the commission. All students must send a copy of their thesis to the members of the commission, together with an evaluation of their career made by the Council at least 15 days in advance. Copies of the thesis must be sent to specific libraries. At the exam each student has about 20 minutes to present his/her thesis and then a discussion follows. The exam is public and the public can participate to the discussion. At the end of each discussion the commission states whether the student has passed and whether he will be granted the title of doctor. The result of the exam is either pass or fail, without a mark; it is extremely unlikely that the candidate fails, since the tutor has followed his/her activity and in case of a poor thesis suggests the student to delay the presentation by 1 year.

**Some generalized remarks on PhD and Doctoral studies.**

Currently, Italian Doctoral schools are also in transition period and subject to many changes due to a newly introduced law that will be active from this year.

Italian PhD study is focused on research mostly and is oriented to prepare specialists to meet industry needs in technology development trends and public administration. In Uzbek doctoral study, more focus is given on teaching and pedagogic issues and preparing not a researcher but a teacher-researcher.

Doctoral study programs particularly in engineering areas need to be integrated with industry to make local industry more competitive and flexible to meet market demands at large. For this reason, there must be very strong links between university (academia) and industry.

More attention must be paid to fundamental/basics study of chosen subject areas in Doctoral programs that will be essential in the future and long run.