

**Proposal of a PhD Programme (PhD)
administered at the Politecnico di Milano**

PhD in: **PHYSICS**

CYCLE:..... **XXVIII**

TYPE OF ACTIVATION PROPOSAL:

- A.) Re-proposal of a PhD already activated – no change to the training project
- B.) Re-proposal of a PhD already activated – no substantial changes to the training project
- C.) Re-proposal of a PhD already activated - substantial changes to the training project
- D.) Newly activated PhD (not applicable for the XXVIII cycle)

Proposing Department: **PHYSICS**

Other proposing departments:.....

POLITECNICO DI MILANO



PhD School of the Politecnico di Milano

Regulations of the PhD Programme in PHYSICS XXVIII Cycle

Campus: Milano Leonardo

(document to be submitted in English or in English+Italian)

1. General Information

PhD School of the Politecnico di Milano

PhD Course: **PHYSICS**

Official Language(s): English/Italian

PhD Programme campus: Milano Leonardo

PhD School Website: <http://www.ricerca.polimi.it/phd>

PhD Programme Website: http://www.fisi.polimi.it/en/teaching/teaching_offer/phd

2. General presentation of the PhD Programme:

(Please use the text registered in the MIUR database – Remember to highlight the possible presence of Areas, Research topics with a short description of the Department(s) research activities

Transformation of scientific knowledge into new technology and transfer of innovation into the production system represent a necessary step for many companies, also dictated by an increasingly global market. For this purpose a figure with a broad cultural background is needed. In particular, many advanced sectors of industry and research require a good knowledge in topics such as condensed matter physics, optics, laser technology and physical instruments and nanostructured materials.

The aim of the PhD in Physics at the Politecnico di Milano is the training of personnel with strong research capacity, to operate in basic and applied research and development facilities, able to manage and design high-tech and innovative products and processes in various industrial sectors. This application-oriented character distinguishes clearly the present PhD course in Physics from those at the School of Science.

The education contents are strictly related to the research activities carried out in the laboratories at the Department of Physics. They can be divided into two main areas:

1) Laser Physics, Photonic Devices and Applications

(optics and quantum electronics, including biomedical applications of lasers, laser applications in optical communications; diagnostics for works of art; time-resolved optical spectroscopy; ultrashort light pulse generation and applications; UV and X optical harmonics generation)

2) Solid State Physics: Advanced Spectroscopy, Scanning Probe Microscopy, Nanostructure Fabrication

(photoemission; spin-resolved electronic spectroscopy; magneto-optics; X ray diffraction; magnetic nanostructures for spintronics; synchrotron radiation spectroscopy, positron spectroscopy, semiconductor nanostructures)

These research activities make use of advanced experimental laboratories located at the Politecnico di Milano (Milan-Leonardo Campus and Como Campus), including:

- Electron spectroscopy with spin resolution
- Magneto-Optics
- Growth and characterization of magnetic nanostructures for spintronics
- Scanning Auger Microscopy (SAM)
- Scanning Near-field Optical Microscopy (SNOM)
- Spectroscopy with synchrotron radiation
- Spectroscopy with positrons
- Epitaxial semiconductor nanostructures for electronics and optoelectronics
- Optical and electron beam lithography
- Biomedical applications of lasers
- Optical spectroscopy in diffusive media
- Applications of lasers in telecommunications
- Optical fibers and waveguides
- Generation of ultrashort pulses
- Spectroscopy with femtosecond time resolution

Moreover, many collaborations are in place with high level international institutions, such as: European Synchrotron Radiation Facility (ESRF) in Grenoble, Polytechnic University of Zurich (ETH) and Lausanne (EPFL), Ecole Polytechnique -Palaiseau (Paris), Paul Scherrer Institut (PSI), Institut de Ciència de Materials de Barcelona, Institut d'Electronique Fondamentale Université Paris-Sud, Argonne National Laboratory, Technical University of Denmark, Royal Institute of Technology (KTH, Stockholm), Max Planck Institute-Stuttgart, University College London, Interuniversitair Micro-Elektronica Centrum (IMEC) Leuven Belgium. Students in our PhD programme will therefore have a real opportunity to gain experience also in prestigious laboratories abroad.

3. Mission and Goals:

The main purpose of the PhD Programme in Physics at the Politecnico di Milano is the development of an experimental approach in problem solving techniques and the attainment of a high level of professional qualification. Scientific education and training to develop general research abilities in all areas of applied physics is increasingly needed by advanced technological industries in Italy, especially northern Italy. The PhD aims to provide engineers and physicists, after a Bachelor of Science ("Laurea", 3 years) and a Master of Science ("Laurea Magistrale", 2 years), with a general education in the basic areas of applied physics and specific knowledge in condensed matter physics, optics and lasers.

4. Professional opportunities and employment market

The PhD at the Politecnico di Milano offers a wide range of opportunities in the fields of advanced technologies, such as photonics and optoelectronics (lasers, optical disks, optical communications), vacuum technologies (thin film depositions), material technologies (microelectronics and nanotechnologies, micromechanical processing), advanced physical instrumentation (electronic and

atomic microscopy, nuclear magnetic resonance) and biomedical optics (optical tomography).

Concerning Italy and similar countries, the following professional profiles are well established:

- Manager of devices, equipment and systems (see above) to solve methodological and technological problems within large industries and companies.
- Designer of optoelectronics advanced devices and systems relying on a physical background and competencies in optics and laser technologies to promote, design and realize new components and devices in high-tech industries as well as small innovative firms.
- Researcher in industries, universities, research centres operating in the technological areas outlined above.

Interesting opportunities are found also at the international level, where technological innovation is even more relevant than in the national scenario. In this frame, the PhD programme in Physics at the Politecnico provides excellent preparation for a highly competitive international arena.

5. PhD Programme Enrolment

5.1 Admission requirements

Italian and foreign citizens can apply. They are required to have graduated in accordance with the pre-existing laws MD 3.11.1999 n. 509 or to have a master of science degree in accordance with MD 3.11.1999 n. 509 or a master of science in accordance with MD 22.10.2004 n. 270 or similar academic qualification obtained abroad, equivalent in duration and content to the Italian qualification and for an overall duration of university studies of at least five years.

Knowledge of the English language to at least B2 level is required.

Admission to the programme will be decided according to evaluation of the academic curriculum, the cover letter and to the development of possible PhD research which candidates must submit together with their application in reply to the admission call.

5.2 Admission deadlines and number of places available

The number of places available is indicated in the call for admission to the 28th PhD Programme cycle:

<http://www.polimi.it/phd>

Scholarships both on general and on specific topics are available, in accordance with that specified in the admission call

6. PhD Programme Contents

Qualification attainment requirements

Attainment of a PhD in **Physics** requires study and research activity of at least three years full-time equivalent study, research and development of the PhD thesis.

The PhD in **Physics** foresees **30** credits to be acquired from PhD level courses, plus **10** credits from either PhD level courses or Master degree courses. Details can be found in paragraph 6.3 below.

6.2 Development of research and the PhD thesis

The aim of PhD programmes at the Politecnico di Milano is the development in candidates of a research-oriented mind-set, with expertise and skills in a specific research topic.

To develop a research-oriented mind-set, candidates must acquire problem-solving capabilities in a complex context, including in-depth analysis of the problem, identification of an original solution and the capability of evaluating a solution and its applicability in given contexts.

These skills provide PhD candidates with major opportunities of development in their research both in the academic field and in public and private organisations.

The main objective is the development of an original research contribution. The PhD thesis must contribute to increasing knowledge in the research field of the candidate. Besides, it has to be coherent with the research topics developed in the department, in which the PhD Programme chosen by the candidate, is carried out.

The original research has to be submitted via a PhD thesis which contains and discusses the contribution, also in the field of the state of the art in the research community on the research issue. The PhD research will be developed according to the guidelines of a supervisor, who supports the candidate in the setting-out and in the everyday activities regarding the development of the thesis. The supervisor does not have to be a member of the Academic Board and can also belong to an institution other than the Politecnico di Milano. The supervisor can be supported by one or more co-supervisors.

To develop the capability of carrying out research activities, the candidate must attend courses according to the PhD programme, defined for his/her study plan and pass them with a positive evaluation.

For each candidate admitted to the programme, a tutor, belonging to the Academic Board, is appointed. The tutor supervises and supports the candidate in the overall training path. The supervisor and the tutor can coincide. The choice of courses will be overseen by the tutor, and will be formalized in a study plan and approved by the Coordinator of the PhD Programme.

Other activities for the development of personal skills and research expertise are encouraged during the PhD programme.

The candidate must acquire the capability to present and discuss his/her work in his/her research community.

Consequently both participation in international conferences and publication of research results in international journals with review are encouraged.

Candidates are also encouraged to carry out part of their research activities in contact with other research groups in their field of interest, preferably abroad.

Research visits of at least three months are strongly encouraged to research groups through which the candidate can acquire further skills to develop his/her research work and the thesis.

The duration of the programme is normally three years.

6.3 Objectives and overview of teaching activities

The Ph.D. Programme and the Ph.D. School may activate various types of training with different valences (courses, seminars, project workshops, laboratories). All activities will aim at:

- creating common starting knowledge for the PhD programme;
- examining the basic research issues (problems, theories, research methods) which represent the cornerstone of the PhD Programme and which identify clearly its cultural position;
- exploring in a specialised manner certain research topics related issues developed in the thesis.

Courses are offered in English, unless otherwise provided for individual courses.

At least one path entirely in English is foreseen in the PhD programme.

Certain teaching activities entitle to acquisition of ECTS credits (Structured teaching activities); other activities, typically specialised and for which it is difficult to make an assessment of learning and quantification of the same, fall within the scientific activities which the Academic Board will take into account in the overall assessment, but whose value is not quantified in ECTS.

Education Program

Training is organised over three years corresponding to 180 credits (ECTS): 40 ECTS (basic training) must be acquired from lecture-based courses and 140 ECTS are devoted to specific training, including research activities and development of the PhD thesis.

Basic training consists of **40** ECTS. A first **10** ECTS course (1st year, 1st semester, mandatory for all PhD students in Physics) is devoted to a Laboratory of Basic Physics: the student will join full time different experimental laboratories, guided by their tutor as well as other colleagues from the Department of Physics. One **5** ECTS course must be taken from the courses offered by the PhD School (chosen by the student among the courses in the corresponding list, see

<http://www.ricerca.polimi.it/index.php?id=4584>). A further **15** ECTS must be acquired choosing courses among those specifically designed for the PhD programme in Physics (the Physics Department offers 30 credit courses). The remaining **10** ECTS must be chosen from either PhD level courses (any PhD programme or PhD School) or any Master Degree courses.

At the end of each year, the work carried out (both courses and research activity) will be verified through a presentation to the Faculty.

The tables below show the foreseen path for candidates and refer only to coursework activities. At the same time, the programme foresees that the candidate is devoted to research activity in a

continuous manner, following the guidelines of his/her Supervisor and of the Academic Board.

First and Second Year

<i>Courses</i>	<i>Possible details</i>	<i>Number of credits (min-max)</i>	<i>Note</i>
<i>PhD School Courses</i>		<i>Min 5 – Max 15</i>	<i>Chosen from the corresponding list</i>
<i>Laboratory of Basic Physics</i>	<i>See table A</i>	<i>10</i>	<i>Mandatory</i>
<i>Courses characterising the PhD Programme</i>	<i>Table A:</i>	<i>Min 15 – Max 25</i>	<i>Chosen among the 30 ECTS courses offered by the Physics Dept.</i>
<i>Master Degree courses</i>		<i>Min 0 - Max 10</i>	
<i>Other PhD courses</i>		<i>Min 0 - Max 10</i>	

Third year

In the third year the candidate should be devoted entirely to research and development of the PhD thesis.

PhD PROGRAMMES

A) The PhD Programme in Physics organises the following **Characterising Courses** (see table A) For admission to the final exam acquisition of at least 25 credits is **mandatory**. These credits must be acquired via the “characterising” PhD courses offered by the PhD Programme.

B) The PhD School organises every year general and Interdoctoral courses and courses with foreign professors. Acquisition of **at least 5 credits** is **mandatory** from type B courses

C) Other PhD courses and/or Master Degree courses

Up to 10 ECTS can be acquired from courses chosen among the PhD courses of type A or B, or from other courses provided by other PhD programmes of the Politecnico and/or any Master Degree courses of the Politecnico.

SPECIALISTIC COURSES, LONG-TRAINING SEMINARS

Attendance of Specialist Courses, Workshops, Schools, Seminars cycles is strongly encouraged and (if these seminars, workshops are certified and evaluated) may permit acquisition of credits according the procedures established by the Academic Board and prior approval of the study plan submitted by the candidate.

These courses and workshops can be inserted in the study plan, even if they are not evaluated (and therefore not qualified as credits), as optional “supplementary teaching”.

In the following table, the schedule for the 2012-13 and 2013-14 academic years is provided. It is possible that other courses are subsequently activated at the PhD School; in this case candidates will be promptly informed in order to be able to insert these new courses in their study plan.

Table A: PHD COURSES CHARACTERISING THE PHD PROGRAMME

SDS	Name of Course	Professor	A.Y./Semester	Language	Credits
FIS/01	Laboratory of Basic Physics	P. Taroni	1/1	English	10
FIS/01 – FIS/03	Photon migration and wave diffusion in random media	A.Torricelli		English	5
FIS/01 – FIS/03	Nano and nanobio-particles and structures	P. Taroni		English	5
FIS/01 – FIS/03	Complementary Quantum Physics	F. Ciccacci		English	5
FIS/03	Theory of electronic structure of solids	P. Folegati		English	5
FIS/03	Spectroscopy of Solids	L. Braicovich		English	5
FIS/03	Plasmonics	P. Biagioni – G. Della Valle		English	5

6.4 Study plan submission

Each PhD candidate must submit his/her study plan. Candidates will have the opportunity to review it periodically (every three months) in order to adapt it to possible changes in the training offer or to needs justified by the development of his/her study plan. The study plan is approved by the Coordinator of the PhD Programme, according to the procedures established by the Academic Board of the PhD Programme itself.

6.5 Annual exam procedures

Every year the candidate is evaluated for admission to the next year.

In the annual exam of the third year, admission of the candidate to the final exam (held by the external Commission) is evaluated. The candidate presents his/her work to the Academic Board at least once a year. After each annual evaluation, the candidate will receive an evaluation (A/B/C/D) or,

if the candidate does not pass the exam, the candidate will be qualified as a “Repeating candidate”(Er) or “not able to continue with the PhD (Ei)”.

In the last year, candidates having achieved sufficient results but who need more time to write their thesis may obtain an extension up to a maximum of 12 months.

6.5 Other foreseen reviews

6.6 PhD thesis preparation procedures

The PhD study and research work will be carried out, full time, during the three years of the PhD course. The possibility of internships or study periods in Italian or foreign companies or external entities and universities is foreseen.

The main objective is the development of an original research contribution.

The PhD thesis must contribute to increasing knowledge in the research field of the candidate.

The thesis must also be coherent with the research issues developed in the department in which the PhD programme, chosen by the candidate is developed.

The candidate must present the original thesis, discussing its contribution to the state of the art in the research field in the research community.

The PhD research will be developed following the guidelines of a supervisor who supports the candidate in setting out and in everyday activities regarding development of the thesis.

On termination of studies, admission of the candidate to the final exam will be evaluated by the Academic Board and, subsequently a final exam is taken in order to attain the qualification, in which the research work carried out and the thesis will be evaluated by an Examination Committee composed of three members, of which at least two external examiners.

7. Laboratories, PhD Secretary Services

Students will join different advanced research laboratories of the Department of Physics, learning about experimental techniques, contributing to research activity and attending meetings and internal seminars aimed at providing a more in-depth knowledge on research topics. A non comprehensive list of experimental laboratories is provided below.

Inverse Photoemission

Spin resolved electronic Spectroscopy

Magnetic nanostructures for spintronics

Magneto-optics

Techniques for electron microscopy

Synchrotron Radiation Spectroscopy

Positron Spectroscopy

Semiconductor nanostructures

Biomedical Applications of Lasers

Lasers for Telecommunication

Diagnostic Techniques for the Works of Art

Optical Fibers and Waveguides
Time resolved Spectroscopy with Femtosecond Resolution
Generation of Ultrashort Pulses
Laboratory of Optical and Electronic Litographic Techniques

PhD Secretary Services:

Stefania MOSCA
Department of Physics
Tel.: 02 23996136
Fax: 02 23996126
e-mail: Stefania.Mosca@ceda.polimi.it

8. Internationalisation and other activities

Carrying out study and research at other laboratories is strongly recommended.
The University also offers the possibility of PhD programmes with foreign universities as well as double and joint PhD programmes. Further information can be found on the PhD School and PhD programme websites