Second cycle degree/Master programme in Physics

Materials Physics and Nanoscience (MANO)
“MANO” is the Italian word for “hand”. Materials Physics and Nanoscience is devoted to the study of materials and structures on the scale of nanometers. The MANO curriculum will provide the students the knowledge and skills to handle matter at the nanoscale.

The MANO curriculum is part of the second cycle degree (master) in Physics (Laurea Magistrale in Fisica). This course will lead students on an exciting path in the study of Condensed Matter Physics, with a particular emphasis on the properties of nanostructures be published on the course website.
The learning areas are organized into teaching blocks, including the thesis activity, corresponding to 120 ECTS total, in two years time. Students will become familiar with the properties of condensed matter, the relevant predictive models, the main experimental and theoretical/computational tools and the quantum effects which become predominant at the nano- level. During the first year the students will acquire the basic principles underlying the rich, fascinating and often unexpected properties of materials and nanostructures necessary to perform nanoscience research at the forefront of knowledge.

In the second year, students will spend most of their time on a thesis project in which they will spend most of their time with thesis project where they will be part of a research group working on an original topic on innovative advanced materials with experimental, computational and/or theoretical tools. The thesis project research activities can be performed in Bologna or elsewhere, in one of the partner Institutions, Universities, Laboratories, High Tech companies, or Large Scale Research Infrastructures available in Italy or Europe, with which the MANO faculty has strong scientific ties.

The international and innovative character of the MANO course is assured by new tools and methods of teaching, where research results and methods will be directly available to students in the form of seminars and workshops. As part of their learning experience, the students will attend, besides traditional lectures, group discussions, laboratory training sessions and they will perform team and individual projects. The students will also develop cross-cutting abilities, such as skills on presentation, discussion and dissemination of scientific data, also targeted to the general public. Methods for the technological exploitation of innovative methodologies will be stressed and the skills required for writing a successful project or experiment proposal will be developed.

**REQUIREMENTS AND ADMISSION TEST**

Since MANO is part of the second cycle degree in Physics, the perspective students should have a 1st cycle Degree (Bachelor’s Degree) in Physics or a comparable diploma; they are expected to be familiar with the basics of fundamental classical and quantum physics. The selection is based on the assessment of applicants’ dossier and interview. Since MANO is a Master degree course entirely taught in English, English language proficiency – B2 level - is required. In absence of the B2 certificate, English proficiency will be assessed through an interview. The calendar of admission tests will be published on the course website.
Programme Structure

First Year

Laboratory of Condensed Matter Physics.
6 ECTS, 1st semester, mandatory.
The student will be able to design a complete experimental apparatus able to implement advanced condensed matter physics experiments. The student will also acquire basic skills to critically elaborate and interpret experimental data. The sound hands-on laboratory training will allow the student to achieve advanced capabilities in equipment handling and experimental problem solving.

Symmetries, Electrons and Phonons.
6 ECTS, 1st semester, mandatory.
The student will learn the basic notions regarding: symmetries of the atomic structure of molecules and crystals and their description using group theory, electronic states in crystals in the independent electron approximation (band theory) and lattice vibrations in classical and quantum approaches.

Interactions and Correlations in Condensed Matter.
6 ECTS, 1st semester, optional.
The student will learn the fundamentals of advanced theoretical condensed matter physics, in particular regarding band theory, electron-electron interactions, Mott transition, superfluidity, electron-phonon interaction and elements of BCS superconductivity; magnetic systems and phase transitions.

Laboratory of Nanoscience and Nanotechnology.
6 ECTS, 2nd semester, optional.
The student will be able to implement and perform experiments at the nanoscale on advanced materials, both in terms of fundamental principles and advanced experimental tools for the growth and characterization of nanomaterials. The student will acquire the basic skills needed to critically elaborate and interpret experimental data.

Charge Transport and Optics in Condensed Matter
6 ECTS, 2nd semester, optional.
The student will learn the basic aspects of the transport and optical properties of condensed matter, from a classical to a quantum-mechanical approach with non-interacting electrons.

Magnetism and Superconductivity.
6 ECTS, 1st semester, optional.
The student will learn the basic quantum phenomena occurring in magnetic and superconducting materials and several experimental techniques employed to study these properties, both on macroscopic and microscopic scale. The student will become familiar with several magnetic and superconducting materials and with their importance for current research and for technological applications.

Thermodynamics and Kinetics of Solids, Surfaces and Nanostructures.
6 ECTS, 2nd semester, optional.
The student will learn the rules that govern thermodynamic equilibrium in condensed phases, from 3-dimensional bulk solids down to nanostructures and 2-dimensional systems. The student will be able to analyze non-equilibrium processes, and important phase transformations such as nucleation and growth.

X-Ray and Synchrotron Radiation Physics.
6 ECTS, 2nd semester, optional.
The student will learn the basic notions regarding the physical mechanisms of the interaction between x-rays and condensed matter in both a macroscopic and microscopic approach and the most important properties of synchrotron radiation sources, with emphasis on the underlying physics. Moreover, the student will learn the basics of the main experimental x-ray methods (x-ray diffraction, x-ray absorption spectroscopy and photoemission) and their recent application to current research topics.

Semiconductor Materials and Nanostructures.
6 ECTS, 1st semester, optional.
The student will learn the basic aspects of: the physics of semiconducting materials, devices, and interfaces their transport and optical properties, the quantum confinement effects at low dimensional systems and their application to optoelectronic and electronic devices.

Quantum Theory of Matter.
6 ECTS, 1st semester, optional.
The student will acquire theoretical tools for modelling quantum states of matter and radiation; the phenomenology and the models related to quantum phenomena of interaction of matter with radiation and quantum theory of radiation; second quantization of fermions and applications to some interacting systems, such as superconductors.
PROGRAMME STRUCTURE

Second year

2 elective courses among those offered at University of Bologna in Physics, Chemistry, Engineering

2 elective courses among those offered at University of Bologna in Physics

From 3 to 6 ECTS of professional activities.
This activity consists in a practical project related to the use of laboratory instrumentation, software packages and/or on-line research tools. This can be performed in Bologna University or in partner institutions.

Master thesis/ Final examination 48 ECTS
During the thesis, the student performs an original research project under the guidance of a University of Bologna supervisor. He/she then writes a dissertation in English outlining the results. The dissertation is presented and discussed with an examination committee, including a specifically appointed referee. The final examination aims at verifying the student’s ability in accomplishing research working as an independent professional and presenting with clarity and competence the results of an original research project, of experimental, computational and/or theoretical nature.

CAREER OPPORTUNITIES

The Program of the MANO curriculum is designed for students seeking a career with an international dimension in different fields: scientific research, advanced technology, new materials and devices. Innovative companies at international level will be selected and one-to-one placements will be organized. The MANO Course will also prepare for further studies at PhD level and academic or professional careers in leading Universities or other research-orientated organization in public and private sectors.

Nowadays, research in nanoscience requires qualified experts with cross-disciplinary expertise, able to manage, generate and contribute to the development of innovative materials and devices able to respond to many societal challenges, such as the development of low carbon economy, secure and sustainable environmental protection, the development of low cost and low power consumption sensors and electronics. These challenges can benefit from experts in the field of materials physics and nanoscience.
INFORMATION & CONTACT

PROGRAMME DIRECTOR: Prof Elisa Ercolessi

COURSE OFFICE: Bologna

TUITION FEE: about € 2,800.00

Further info: http://corsi.unibo.it/2cycle/MANO

STUDY GRANTS FOR INTERNATIONAL STUDENTS:
www.unibo.it/en/services-and-opportunities/study-grants-and-subsides/grants-for-international-students-unibo-action2

For further information please contact: Prof Daniela Cavalcoli
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THE UNIVERSITY OF BOLOGNA

Born in 1088, and considered to be the oldest university in the Western world, the University of Bologna has been student-centred, attracting prominent figures from science and the arts. Today it is a leader in Europe and famous for its beauty and integration with the city. Its teaching catalogue is diversified and tailored to the needs of present-day society: over 200 degree programmes, over 70 professional masters a 45 PhD programmes, 41 specialisation courses, all among its 33 Departments, 11 Schools and over 81,000 students. Bologna has always favoured a multi-disciplinary, cross-cultural approach; it invests in international, multicultural training, research and services. It has formed knowledge alliances with industry and public/private organizations, and is a hub of international networks. 

Besides the five campuses (Bologna, Cesena, Forlì, Ravenna, Rimini), there is an overseas branch (Buenos Aires) coordinating activities with Latin America. Beyond its close European links, Alma Mater enjoys multiple international connections with North America, Africa, Asia and Australia. It is a public, independent and pluralistic institution.