HEADING

Degree classification - Denomination and code: L-30 Physics
Degree title: Dottore
Length of course: 3 years
Total number of credits required to complete programme: 180
Years of course currently available: 1st, 2nd, 3rd
Access procedures: Open, subject to completion of self-assessment test prior to enrolment
Course code: F63

PERSONS/ROLES

Head of Study Programme
Prof.ssa Alessandra Guglielmetti

Tutors - Faculty
Tutor per l'orientamento (Academic guidance tutor)

Tutor per i piani di studio (Study plan tutor)
A. Guglielmetti

Tutor per la mobilità internazionale e l'Erasmus (Erasmus and International mobility)
N. Piovella

Tutor per stage e tirocini (Internship tutor)
N. Piovella, A. Guglielmetti

Tutor per laboratori e altre attività (Laboratory Classes)
R. Vecchi

Tutors - Students
ANDOLFATO BIANCA
NSELMI GIOVANNIMARIA
ASINARI LUCA
CHEMOLI DARIO
CHIAPPERINO FRANCESCO
CHINI GIOVANNI
Crippa FRANCESCO
DANELLI MARIA
DE NARDI GIACOMO
FARINELLI FRANCESCO
GIUNTA CHIARA
PELLEGRINI GIOVANNI

Degree Course website
https://fisica.cdl.unimi.it/it

Dissertation and Final Exam
L. Bonizzoni (Presidente), C. Benedetti, F. Camera, S. Carrazza, V. Liberali, D. Maino

Laboratory Security
M. Potenza
CHARACTERISTICS OF DEGREE PROGRAMME

General and specific learning objectives
The Bachelor's Degree program in Physics aims to enable the student to continue with higher studies or to start a professional activity. The program gives students the methodological, experimental, theoretical, mathematical basis on which Physics is based. Knowledge will be acquired of classical, relativistic and quantum Physics, as focused on phenomenological and theoretical aspects as well as on their mathematical formalization.

Expected learning outcomes
Based on the Dublin descriptors, graduates of the Bachelor's degree programme in Physics will develop the following competencies:

A) KNOWLEDGE AND UNDERSTANDING
Bachelor's graduates in Physics will gain:
- Knowledge and understanding of the scientific method;
- Knowledge and understanding of classical physics: mechanics, thermodynamics, electromagnetism, optics and wave propagation, fluid dynamics, analytical mechanics;
- Knowledge and understanding of modern physics: quantum mechanics, quantum theory of matter, nuclear and subnuclear physics, restricted relativity;
- Knowledge and understanding of chemistry (with regard to the basics);
- An understanding of the cross-disciplinary aspects of studying physical phenomena and the ability to frame problems in a wide-ranging historical and scientific context;
- Mathematical knowledge: mathematical analysis, linear algebra and geometry, complex analysis, elements of functional analysis;
- Computer science knowledge: procedural programming and object-oriented programming, solving problems using numerical methods, computer networks;
- Basic knowledge of electronics and electronic instruments: analogue electronics, elements of digital electronics, use of tools and simple systems for data acquisition;
- Intermediate knowledge in a specific branch of physics, such as: astrophysics; environmental physics; medical physics; statistical physics; Earth physics; general relativity.
B) APPLYING KNOWLEDGE AND UNDERSTANDING
Bachelor's graduates in Physics will be able to:
- Use the scientific method to study physical phenomena and analyse experimental data;
- Design and/or develop simple mathematical models of reality;
- Carry out simple laboratory measurements using modern tools and process data using statistical methods and computing platforms;
- Use physical signal sensors and/or detectors as well as measurement tools, including computer controlled tools;
- Use the specific instruments of one of the following fields: astrophysics, nuclear physics, physics of matter, electronics, optics, laser, environmental physics;
- Work in team: this ability will be acquired during the experimental teaching laboratories and the computational physics laboratory, and/or in research groups, also outside of the University, while working on the final paper.

C) MAKING JUDGEMENTS
Bachelor's graduates in Physics will be able to:
- Assess and interpret experimental data collected in the laboratory;
- Assess the implications of experimental data collected in the laboratory or made available by research agencies in critical applications (e.g. biomedical imaging, dosimetry, avionics, automotive sector);
- Reflect on the social and ethical responsibilities related to the application of knowledge;
- Autonomously assess the various aspects of teaching;
- Assess themselves in a scientific context and/or with a view to their entry into the job market.

D) COMMUNICATION SKILLS
Bachelor's graduates in Physics will be able to:
- Communicate effectively both orally and in writing, with appropriate language and scientific rigour, adjusting the level of details and the communication focus accordingly;
- Describe experimental and theoretical results using modern presentation techniques, including multimedia technologies;
- Properly communicate in English (B1 level);
- Have a good grasp of the English language, particularly with regard to the scientific vocabulary and the technical terms of physics.

E) LEARNING SKILLS
Bachelor's graduates in Physics will be able to:
- Effectively use textbooks and scientific publications written in English;
- Carry out bibliographic searches;
- Consult databases and electronic journals;
- Consult textbooks and specialised journals in a particular field of physical research.

**Professional profile and employment opportunities**

**Professional Profile and Career Opportunities**

The course prepares students for the profession of physics and nuclear technician.

Graduates typically continue their education in higher studies, but they can also pursue careers in industries and public and private institutions, working in facilities such as:

- Research centers and laboratories
- Hospitals and healthcare facilities that utilize techniques for diagnostics, therapy, and radiation protection
- Astronomical observatories
- Museums and other centers dedicated to scientific outreach
- Banks and insurance companies
- Facilities dedicated to the development of mathematical and statistical models of phenomena
- Facilities dedicated to the use and development of complex systems and instruments or data acquisition and processing
- Institutions involved in the restoration of artistic assets and the preservation of environmental goods
- Power plants (including nuclear power plants)
- International centers for nuclear energy control and the prohibition of nuclear weapons

The functions that graduates will perform in the work environment include, for example:

- Analysis and scientific understanding of measurable phenomena of interest
- Design and development of simple prototypes
- Efficient utilization of measurement instruments and their development
- Conducting measurements of natural phenomena (e.g., radioactivity, electromagnetic fields, etc.)
- Data analysis, including statistical analysis ("data scientist")
- Development of mathematical and statistical models in a wide range of contexts (mechanics, finance, medicine, etc.)
- Control of industrial processes and quality assurance
Dissemination and promotion of scientific culture
Technical and scientific training of personnel and/or external users
Designing innovative educational proposals
Preparation of scientific reports (reports, books, essays, etc.)

Initial knowledge required
Admission requirements
Qualifications and knowledge required for admission
Applicants to the Bachelor's degree programme in Physics must hold an upper secondary-school diploma or an equivalent qualification obtained abroad.
Admission to the programme is open, subject to a mandatory, non-selective assessment test before enrolment. The test is aimed at ascertaining the candidate's educational background, in terms of knowledge and understanding of the basic scientific disciplines, especially mathematics and elementary logic. The test syllabus is available at:

Admission assessment
Candidates are usually assessed through the TOLC CISIA Online Test, to be taken at the University of Milan or any other universities belonging to the Consortium of Inter-University Integrated Access Systems (CISIA). Students have to register for the TOLC test on the CISIA website (www.cisiaonline.it).

Admission of transfer or graduate students
Transfer students from a degree programme of the University of Milan, or another university, and graduate students will be waived from the test requirement only if they are admitted to years subsequent to the first.
For further details, please see the call for applications

The TOLC tests providing access to the degree programme in Physics are TOLC-S and TOLC-I.
Students will be able to enrol only after taking one of these tests, WHATEVER THE RESULT:
- TOLC-S, divided into 4 sections: Basic mathematics (20 questions - 50 minutes), Logic and problems (10 questions - 20 minutes), Reading comprehension (10 questions - 20 minutes), Basic science (chemistry, physics and geology - 10 questions - 20 minutes)
- TOLC-I, divided into 4 sections: Mathematics (20 questions - 50 minutes), Logic (10 questions - 20 minutes), Sciences (10 questions - 20 minutes), Verbal comprehension (10 questions - 20 minutes).
Each question has 5 answer options, of which only one is correct.
Score: +1 for a correct answer, -0.25 for a wrong answer, 0 for not given answers.

Each TOLC test includes an additional English section, consisting of 30 questions to be answered in 15 minutes. This section does not replace the for-credit English proficiency assessment required by the degree programme, but serves as a self-assessment tool for the student.

Other equivalent tests may be accepted on a case-by-case basis, with the prior approval of the Academic Board.

Additional learning requirements (OFA) and remedial activities
First-year students who have not achieved at least 10 points in the Mathematics module will have to fulfil additional learning requirements (OFA) for this subject within the first year of the programme.
Remedial activities and tests: students with additional learning requirements will have to carry out remedial activities in the period October-December, and then pass a test to prove they have filled their gaps. Otherwise, they will not be allowed to take any second-year exams before passing the Mechanics exam (https://fisica.cdl.unimi.it/it/studiare/le-matricole).

Test topics, registration procedures, dates, deadlines and other information are specified in the call for applications:
https://fisica.cdl.unimi.it/it/iscriversi

Compulsory attendance
Attendance is compulsory and will be monitored in each class for laboratory courses

Degree programme final exams
To obtain their degree, the student must have earned 180 credits, possibly also before the end of the three-year period.
The paper consists of an individual work carried out by the student under the guidance of a supervisor.
It is also possible to work on the final paper in external public or private entities, under the guidance of both an external and an internal supervisor.

Before starting thesis work, the student is required to submit an application (with a tentative thesis title) to the Degree Board for approval. The board will grant any applications that are consistent with the study programme, and assign each student their supervisor(s) and co-supervisor(s).
Following a resolution of the Academic Board, students enrolled in the second year in 2021/2022 or in subsequent years are required to pass the electromagnetism exam before they are assigned a thesis.
The official thesis assignment is a MANDATORY step to be taken before starting thesis work. Thesis supervisors and co-supervisors thereby take responsibility for and are required to check all formal aspects, including for insurance purposes. The thesis application must be submitted online at https://registrazione.fisica.unimi.it/richiesta-tesi/login

To be admitted to the final exam, the student must have earned 172 CFU. Moreover, there must be consistency between academic records and the last approved study plan.

Thesis defense marks the completion of the study programme, and the graduate can enter the world of work or enrol on a Master's degree programme

Notes
For-credit assessment B1
In order to obtain their degree, students must be proficient in English at a B1 level under the Common European Framework of Reference for Languages (CEFR). This proficiency level may be certified as follows:
- By submitting a language certificate attesting B1 or higher level in English and issued no more than three years before the date of submission. You will find the list of language certificates recognized by the University at: https://www.unimi.it/en/node/39322). The certificate must be uploaded during the enrolment procedure, or subsequently to the portal http://studente.unimi.it/uploadCertificazioniLingue;
- By taking a placement test offered by the University Language Centre (SLAM) between October and December of the first year. Students who fail the test will be required to take a SLAM course.
The placement test is mandatory for all those who do not hold a valid certificate attesting to B1 or higher level.
Those who have not taken the placement test by the end of December or fail the end-of-course exam six times must obtain the necessary certification privately before graduating.

As a further requirement for graduation, the student's proficiency in scientific English language (English Language 2) will be assessed in one of the following ways:
1. the delivery of a written Laboratory Report in English
2. carrying out and passing one of the curricular examinations in English
3. attending a course delivered in the English language
4. training activities related to the final thesis executed in the English Language

EXPERIENCE OF STUDY ABROAD AS PART OF THE TRAINING PROGRAM

Experience of study abroad as part of the training programme

The University of Milan supports international mobility by providing its students with the opportunity to spend study and internship periods abroad. It is a unique chance to enrich your educational path in a new exciting environment.
The agreements entered into by the University with over 300 universities from the 27 EU member countries under the European Erasmus+ programme allow regularly enrolled students to carry out part of their studies at one of the partner universities or to undertake internships at companies, training and research centres and other organizations.
Similar international mobility opportunities are provided outside Europe, through agreements with a number of prestigious institutions.

Study and internships abroad
The thesis work may be occasionally carried out in prestigious research centers like CERN or GSI, or important Universities worldwide, in the frame of international collaborations and research programs.

How to participate in Erasmus mobility programs
How to participate in Erasmus+ mobility programmes

The students of the University of Milan can participate in mobility programmes, through a public selection procedure. Ad hoc commissions will evaluate:
• Academic career
• the candidate's proposed study programme abroad
• his/her foreign language proficiency
• the reasons behind his/her application
Call for applications and informative meetings
The public selection for Erasmus+ mobility for study generally begins around February each year with the publication of a call for applications specifying destinations and requirements. Regarding the Erasmus+ Mobility for Traineeship, the University of Milan usually publishes two calls a year enabling students to choose a destination defined by an inter-institutional agreement or to find a traineeship position on their own.
The University organizes informative meetings to illustrate mobility opportunities and rules for participation.

Erasmus+ scholarship
The European Union grants the winners of the Erasmus+ programme selection a scholarship to contribute to their mobility costs, which may be supplemented by the University funding for disadvantaged students.

Language courses
Students who pass the selections for mobility programmes can benefit from intensive foreign language courses offered each
year by the University Language Centre (SLAM).
https://www.unimi.it/en/node/8/
Learn more at https://www.unimi.it/en/node/274/
For assistance, please contact:
International Mobility Office
Via Santa Sofia 9 (second floor)
Tel. 02 503 13501-12589-13495-13502
Contacts: InformaStudenti; mobility.out@unimi.it
Student Desk booking through InformaStudenti

<table>
<thead>
<tr>
<th>1st COURSE YEAR Core/compulsory courses/activities common</th>
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</thead>
<tbody>
<tr>
<td>Learning activity</td>
</tr>
<tr>
<td>COMPUTER SCIENCE</td>
</tr>
<tr>
<td>English assessment B1 (2 ECTS)</td>
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<tr>
<td>GEOMETRY 1</td>
</tr>
<tr>
<td>MATHEMATICAL ANALYSIS 1</td>
</tr>
<tr>
<td>MATHEMATICAL ANALYSIS 2</td>
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<tr>
<td>MECHANICS</td>
</tr>
<tr>
<td>PHYSICS LABORATORY WITH INTRODUCTION TO STATISTICS</td>
</tr>
<tr>
<td>WAVES AND OSCILLATIONS</td>
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<tr>
<td>Total compulsory credits</td>
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<thead>
<tr>
<th>2nd COURSE YEAR Core/compulsory courses/activities common</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning activity</td>
</tr>
<tr>
<td>CLASSICAL MECHANICS</td>
</tr>
<tr>
<td>ELECTROMAGNETISM</td>
</tr>
<tr>
<td>(5) FIS/07, (10)</td>
</tr>
<tr>
<td>EXPERIMENTAL DATA PROCESSING LABORATORY</td>
</tr>
<tr>
<td>MATHEMATICAL ANALYSIS 3</td>
</tr>
<tr>
<td>OPTICS, ELECTRONICS AND MODERN PHYSICS LABORATORY</td>
</tr>
<tr>
<td>QUANTUM PHYSICS 1</td>
</tr>
<tr>
<td>The exam for this course will be taken in the third year, upon completion of the Quantum Physics module (Module 2), and will result in the verbalization of a single 15 CFU Quantum Physics exam</td>
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<tr>
<td>THERMODYNAMICS</td>
</tr>
<tr>
<td>(3) FIS/07, (3) FIS/01</td>
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<tr>
<td>Total compulsory credits</td>
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<thead>
<tr>
<th>3rd COURSE YEAR Core/compulsory courses/activities common</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning activity</td>
</tr>
<tr>
<td>CHEMISTRY 1</td>
</tr>
<tr>
<td>INTRODUCTION TO NUCLEAR AND PARTICLE PHYSICS</td>
</tr>
<tr>
<td>QUANTUM PHYSICS 2</td>
</tr>
<tr>
<td>STRUCTURE OF MATTER 1</td>
</tr>
<tr>
<td>In the academic year 2024/25, the Structure of Matter 1 course will be offered in two editions, one in the FIRST SEMESTER and one in the SECOND SEMESTER.</td>
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<tr>
<td>Total compulsory credits</td>
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<table>
<thead>
<tr>
<th>Elective courses</th>
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</thead>
<tbody>
<tr>
<td>One course chosen from among</td>
</tr>
<tr>
<td>ASTRONOMY LAB</td>
</tr>
<tr>
<td>(3) FIS/05, (3) FIS/01</td>
</tr>
<tr>
<td>COMPUTATIONAL PHYSICS LABORATORY</td>
</tr>
<tr>
<td>(3) FIS/05, FIS/07, FIS/04, FIS/03, FIS/02, FIS/01</td>
</tr>
<tr>
<td>CONDENSED MATTER PHYSICS LABORATORY</td>
</tr>
<tr>
<td>(3) FIS/03, (3) FIS/01</td>
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<tr>
<td>EARTH PHYSICS LABORATORY</td>
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<tr>
<td>(2) FIS/07, (2) FIS/01</td>
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<tr>
<td>ELECTRONICS 1</td>
</tr>
<tr>
<td>(3) ING-INF/01, (3) FIS/01</td>
</tr>
<tr>
<td>ELECTRICAL LABORATORY</td>
</tr>
<tr>
<td>Course offered every other year: not available in the academic year 2024/25. Its activation is scheduled for the academic year 2025/26</td>
</tr>
<tr>
<td>ENVIRONMENTAL PHYSICS LABORATORY</td>
</tr>
<tr>
<td>INTRODUCTION TO ASTROPHYSICS</td>
</tr>
<tr>
<td>INTRODUCTION TO GENERAL RELATIVITY</td>
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<tr>
<td>INTRODUCTION TO HEALTH AND MEDICAL PHYSICS</td>
</tr>
<tr>
<td>INTRODUCTION TO STATISTICAL PHYSICS</td>
</tr>
<tr>
<td>NUCLEAR PHYSICS LABORATORY</td>
</tr>
<tr>
<td>(3) FIS/03, (3) FIS/02</td>
</tr>
<tr>
<td>NUMERICAL SIMULATION LABORATORY</td>
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<tr>
<td>(3) FIS/03, (3) FIS/01</td>
</tr>
<tr>
<td>OPTICS LABORATORY</td>
</tr>
<tr>
<td>(3) FIS/03, (3) FIS/01</td>
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</tbody>
</table>

It is recommended to choose a Laboratory course from the ones mentioned above.
The student must also acquire 12 CFU by freely choosing from all the courses offered by the University, provided that they are culturally consistent with their educational path and do not overlap in content with the already used fundamental and optional courses in the study plan. This choice also includes all the courses listed in the above table of Elective Activities.

### COURSE YEAR UNDEFINED Core/compulsory courses/activities common

<table>
<thead>
<tr>
<th>Learning activity</th>
<th>Ects</th>
<th>Sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGLISH 2</td>
<td>2</td>
<td>L-LIN/12</td>
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Total compulsory credits: 2

#### End of course requirements

<table>
<thead>
<tr>
<th>Learning activity</th>
<th>Ects</th>
<th>Sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>FINAL EXAM</td>
<td>8</td>
<td>NA</td>
</tr>
</tbody>
</table>

Total compulsory credits: 8

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### COURSE PROGRESSION REQUIREMENTS

The course contains the following obligatory or advised prerequisites

<table>
<thead>
<tr>
<th>Learning activity</th>
<th>Prescribed foundation courses</th>
<th>O/S</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATHEMATICAL ANALYSIS 3</td>
<td>MATHEMATICAL ANALYSIS 1</td>
<td>Core/compulsory</td>
</tr>
<tr>
<td></td>
<td>MATHEMATICAL ANALYSIS 2</td>
<td>Core/compulsory</td>
</tr>
<tr>
<td>MATHEMATICAL ANALYSIS 2</td>
<td>MATHEMATICAL ANALYSIS 1</td>
<td>Core/compulsory</td>
</tr>
<tr>
<td>ELECTROMAGNETISM</td>
<td>MECHANICS</td>
<td>Recommended</td>
</tr>
<tr>
<td>THERMODYNAMICS</td>
<td>MECHANICS</td>
<td>Recommended</td>
</tr>
</tbody>
</table>