UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Physics (blended)

2526-1-E3402Q002

Aims

The course provides the basic notions of general and experimental physics. As such, they represent the common and essential foundation of all scientific disciplines.

O1 – Knowledge and understanding

1. Understand the concept of physical quantity, measurement of a physical quantity, uncertainty of a physical quantity
2. understand the international system of units of measurement
3. understand the definitions, principles and laws of classical physics

O2 – Ability to apply knowledge and understanding

1. Know how to measure a physical quantity and know how to express the value and uncertainty of this quantity and its unit of measurement
2. Know how to apply the definitions, principles and laws of classical physics to real problems

O3 – Autonomy of judgment

Know how to conduct a reasoned analysis of natural phenomena based on the definitions, principles and laws studied.

O4 – Communication skills

Know how to illustrate with proper language the meaning of the definitions, principles and laws of classical physics.

O5 – Learning ability
Be able to apply the skills and concepts acquired to understand and make predictions of real phenomena.

Contents

Elements of mechanics:

Kinematics of the point: position, displacement, velocity, acceleration.

One-dimensional, two-dimensional and rotational kinematics: uniform rectilinear motion, uniformly accelerated motion, parabolic motion, circular motion, harmonic motion.

Dynamics of the material point: Newton's laws of motion. Static, dynamic and viscous friction forces. Work, kinetic energy and power. Conservative forces and systems. Potential energy and conservation of mechanical energy.

Dynamics of systems and rigid bodies: internal and external forces. The motion of the center of mass. Principle of conservation of momentum. Moment of inertia about an axis. Moment of a force. Angular momentum and principle of conservation of angular momentum. Rigid body rotating around a fixed axis. Rolling motion. Equilibrium of a rigid body.

The law of universal gravitation. Orbital motions. Gravitational potential energy.

Fluids: hydrostatic pressure, Archimedes' principle, flow and continuity.

Oscillatory motion: simple harmonic motion, the damped free oscillator, forced oscillations and resonance.

Mechanical waves: Classification of waves. Wave propagation. Energy transported by a wave. Superposition principle. Standing waves.

Elements of electromagnetism:

Coulomb's law. The electric field. The electrostatic potential. The electric dipole. Conductors and insulators.

Capacities and capacitors. Energy density stored in an electric field. Electric current in metal conductors. Ohm's law. The Joule effect. Electrical power.

The Lorentz force and the definition of the magnetic induction field. Magnetic dipoles and notes on the properties of magnetic materials.

The law of electromagnetic induction. Energy density stored in a magnetic field.

Electromagnetic waves and elements of geometric optics.

Detailed program

Lesson (in person)
Introduction to the course and exam methods. Experimental activity and “My Physics Measurement”.

Introduction to vector calculus.

Lesson (in person)
Vector calculus: addition, subtraction, scalar product and vector product.

Exercise (in person)

Lesson (in person)
One-dimensional kinematics. Position, displacement, average and instantaneous velocity, acceleration average and instantaneous.

Exercise (in person) - Experimental determination of pi

Lesson (in person)
Uniformly accelerated motion. Fall of heavy bodies. Kinematics in 3 dimensions: position, displacement, average and instantaneous speed.

Exercise (in person)

Lesson (in person)
Uniform circular motion. Centripetal acceleration. Polar coordinates. Angular kinematic quantities. Harmonic motion. Relationship between position, velocity and acceleration in harmonic motion.

Exercise (in person)

Lesson 1 (ONLINE interactive teaching)
Motion with constant acceleration. Bullet. Parabolic motion.

Lesson (in person)
Point dynamics. Mass and Strength. Principle of inertia.

Exercise (in person)

Lesson (in person)
Newton's second and third laws. Centripetal force and weight force. Motion of a point on an inclined plane. Effort and pressure. Apparent forces.

Lesson 2 (ONLINE interactive teaching)
Elastic forces and Hooke's law. Hooke's law for deformable bodies. Young's modulus. Forces of friction. Static and dynamic friction. Critical angle.

Exercise (ONLINE-1 Interactive teaching) - Vector calculation, Kinematics and Dynamics of the point

Exercise (in person)

Lesson (in person)
Work and Energy. Definition of work in 1D. Definition of work in 2D and 3D: scalar product and line integral. Work done by the weight force. Work done by elastic forces.

Exercise (in person)

Lesson (in person)
Conservative forces and non-conservative forces. Potential energy. Gravitational potential energy e elastic potential energy.

Exercise (in person)

Lesson (in person)
Mechanical energy during the fall of a heavy body. Mechanical energy of the oscillations of a system spring block. Relationship between conservative force and potential energy. Gradient operator. Surfaces equipotential.

Lesson 3 (ONLINE Interactive teaching)
Work-energy theorem. Average and instant power.

Tutorial (ONLINE-2 Self-learning) - Measurement 1 - Calibration of a spiral spring

Exercise (in person)

Lesson (in person)
Dynamics of translational motion. Center of mass of a system. Motion of the center of mass. Moment linear. Law of conservation of momentum.

Exercise (in person)

Lesson (in person)
Energy conservation principle. Gravitation. Law of universal gravitation. Acceleration of gravity.

Lesson 4 (ONLINE Iteractive teaching)
Gravitational field. Gravitational potential energy. Mechanical energy of circular orbits. Escape velocity.

Exercise (in person)

Lesson (in person)
Rotational dynamics. Degrees of freedom and Rototranslations. Rotational kinetic energy. Moment of inertia. Rolling.

Lesson (in person)
Dynamics of rotary motion. Angular momentum of a particle and total angular momentum. Cardinal equations of mechanics. Law of conservation of angular momentum. Dynamics of harmonic motion.

Lesson 5 (ONLINE Interactive teaching)
Static equilibrium of the rigid body. Center of mass of a rigid body. Translational equilibrium and equilibrium rotational. Moment of a force. Center of gravity.

Exercise (ONLINE-3 Interactive teaching) - Energy, Gravitation, System Mechanics

Exercise (in person)

Lesson (in person)
Natural oscillation frequency. Waves. Impulsive wave and periodic wave. Progressive waves e regressive, longitudinal and transverse. Plane harmonic wave function. Wave equation.

Exercise (in person)

Lesson 6 (ONLINE Intearctive teaching)
Mechanical waves. Propagation of p and s waves in a continuous medium. Young's modulus and modulus of

rigidity. Velocity of p and s waves. Intensity of a wave. Attenuation of the intensity of spherical waves.

Lesson (in person)
Fluids. Hydrostatic pressure. Pascal's principle. Archimedes' thrust.

Exercise (in person) - Experimental determination of mass density using a balance

Lesson (in person)
Flow lines. Continuity. Bernoulli's law. Load and load losses. Viscosity.

Lesson 7 (ONLINE Interactive teaching)
Electrostatics. Coulomb force. Electric field. Electric field generated by a point charge and a set of point charges. Field lines. Work done by the electrostatic force.

Lesson 8 (ONLINE Interactive teaching)
Electrostatic potential. Potential generated by one or more point charges. Potential of a dipole. relationship between electrostatic field and potential. Potential gradient. Equipotential surfaces.

Exercise (in person)

Lesson (in person)
Metallic insulators and conductors. Electrostatic properties of metallic conductors. Capacity. Capacitors. Energy stored in a capacitor.

Exercise (in person)

Exercise (ONLINE-4 Self-learning) - Measurement 2 - Photometry of point sources

Lesson (in person)
Current intensity. Drift speed. Current density. Resistance and Ohm's law.

Lesson (in person)
Resistivity. Resistors in series and parallel. Voltage generators. Internal resistance of a generator. Electromotive force. Electric power.

Exercise (in person)

Lesson 9 (ONLINE Interactive learning)
Magnetic induction field. Lorentz force. Force people on a conductor traveled by current. Magnetic field generated by a straight current-carrying wire. Field of one solenoid. Magnetic induction flow.

Lesson (in person)
Electromagnetic induction. Faraday's law of induction. Lenz's law. Induced voltage across a metal bar moving in a magnetostatic field. Self-induction. Inductance of a solenoid. Energy stored in a solenoid.

Exercise (in person)

Lesson (in person)
Electromagnetic waves. Refractive index. Vector of Poynting. Electromagnetic spectrum.

Lesson 10 (ONLINE Interacting teaching) – Online experiment to determine the resistance of the human body to pressure

Exercise (ONLINE-5 Interactive teaching) - Fluid Mechanics, Electrostatics and Direct Current Circuits

Prerequisites

Elements of mathematical analysis

Teaching form

The main activity consists of lessons in person, since, as a fundamental course of the first year, the main objective consists in transmitting the ability to express oneself in scientific language. The hours delivered in person are carried out through the projection of slides which are part of the teaching material, through writing on the blackboard, and through the execution of some measurements and analysis of the acquired data. The online lesson hours are equally divided into exercises with dedicated platforms and lessons structured in an interactive way.

The activity in person and online focuses on understanding the notions included in the two macro-topics: mechanics and electromagnetism. The online exercise activity involves the resolution and evaluation of multiple choice questions extracted from dedicated Test Banks consistent with the topics of the lessons as well as the execution of some physics experiments which involve the acquisition of some measurements.

Total hours

112: 64 lectures + 48 exercises

Hours in person

80 hours: 44 lectures + 36 exercises

Online Hours

32 hours: 20 lessons (Interactive Teaching) + 12 exercises (6 Interactive Teaching + 6 Self-leraning activity)

Textbook and teaching resource

Textbooks:

Gianni Vannini

Gettys Fisica 1 – Meccanica · Termodinamica

McGraw-Hill, IV - V Edizione.

Giovanni Cantatore; Lorenzo Vitale

Gettys Fisica 2 – Elettromagnetismo · Onde (· Ottica)

McGraw-Hill, IV - V Edizione.

G. Bussetti, M. Campione, A. Pietropaolo
Sperimentare la Fisica
UTET Università

Educational material present on the platform:

- lecture slides

- audio/video recordings

- exercises

- glossary

Semester

From 01 - 03 - 2026 to 31 - 06- 2026

Assessment method

Interim evaluations:
During the semester, 6 online tests will be carried out with evaluation:

- 3 online exercises via a specific timed platform, each consisting of approximately 10 multiple choice exercises which provide an evaluation out of thirtieths proportionate to the fraction of correct answers;
- 2 measurement experiments to be carried out at home described by a specific manual. The measurement results will be sent via the elearning platform and will be subject to an evaluation out of thirties by the teacher.

Furthermore, within the first month of the start of the course, each student must formulate a measurement proposal to be carried out by the chosen exam date. In this proposal the student will have to indicate which instrument he wants to use to carry out the measurement and which physical quantity he intends to measure (e.g.: I would like to use the thermometer to measure the temperature of the water inside a glass subjected to microwave oven treatments for different times). The student will be required to illustrate the measurement results during the final test.

The evaluation out of thirty of the exercises will have an indicative weight of 50% on the formulation of the final evaluation.

Final evaluation:
The final evaluation will be formulated on the basis of the evaluation of the official exam session, which includes an oral test on the course topics. At the end of the oral test the commission expresses a mark out of thirty taking into account the result of the intermediate evaluations.
The oral exam takes place in compliance with the following phases:

1. a question on the basic notions of trigonometry and a question on operations with vectors (the student answers by writing on the blackboard)

2. illustration of the results of the proposed measurement (the student can show printed sheets or files on the screen of their PC or smartphone)
3. 2-3 questions on the macro-topics of the theory of mechanics and electromagnetism (the student answers by writing on the blackboard)

An incorrect answer or failure to answer question 1) will result in the exam not being approved.
Following the illustration referred to in point 2), the commission expresses an opinion out of thirty regarding the quality of the results shown (tables and graphs produced) and the appropriateness of the language adopted in the description of the operations carried out. This evaluation will have a weight of 25% on the final judgement.
The answers provided in point 3) will be evaluated out of thirty taking into account the appropriateness of the candidate's language, the ability to connect different topics of the course, and the level of knowledge of the basic definitions. This evaluation will have a weight of 25% on the final judgement.

The following level of judgment is applied in relation to the following parameters:

1. Conceptual knowledge and understanding ability
2. Ability to apply knowledge and understanding
3. Communication and argumentative skills
4. Learning, self-assessment and self-regulation ability

Grade < 18
Knowledge and Understanding: The student only partially identifies the characteristics of the concepts. The connections between the concepts are fragmented and poorly supported by theoretical knowledge.

Ability to apply knowledge and understanding: The student identifies only some relevant elements in a phenomenon, without being able to integrate them into an organic analysis.

Communication and argumentation skills: In the oral exam, the student elaborates an essential argument, lacking logical articulation and characterized by numerous expository inaccuracies.

Learning, self-assessment and self-regulation skills: The student is able to reconstruct only some aspects of his/her learning and professional development path.

Votazione 18-22
Conoscenza e Comprensione: Lo studente riconosce e restituisce la maggior parte delle caratteristiche concettuali e riesce a fornirne una spiegazione relativamente coerente, sebbene con qualche imprecisione. I riferimenti teorici sono presenti ma non sempre in modo rigoroso.

Capacità di applicare conoscenza e comprensione: Lo studente è in grado di riconoscere un numero significativo di elementi e di fornire una spiegazione parziale, pur evidenziando alcune lacune nell’analisi.

Capacità comunicative e argomentative: Nella prova orale lo studente costruisce un’argomentazione di base, dotata di una struttura minima ma con alcune imprecisioni.

Capacità di apprendimento, di autovalutazione e di autoregolazione: Lo studente dimostra una consapevolezza di base del proprio percorso di apprendimento, riuscendo a tracciare collegamenti essenziali tra le esperienze formative, sebbene con alcune imprecisioni.

Grade 23-27
Knowledge and Understanding: The student demonstrates an in-depth understanding of the conceptual characteristics. In the oral exam, the explanations are well-structured and supported by an adequate use of theoretical references.

Ability to apply knowledge and understanding: The student precisely identifies the essential elements of a phenomenon. The application of knowledge occurs with a methodological rigor that is not always solid.

Communication and argumentative skills: In the oral exam, the student develops a coherent and well-organized argument, demonstrating good mastery of language and a solid logical-argumentative structure. Communication is clear and effective.

Learning, self-assessment and self-regulation skills: The student analyzes his/her learning path in a clear and structured way, highlighting significant relationships between the different evolutionary stages and demonstrating a good capacity for critical reflection.

Grade 28-30
Knowledge and Understanding: The student demonstrates a complete mastery of concepts, articulating complex connections and providing exhaustive explanations. Theoretical references are used with relevance and rigor.

Ability to apply knowledge and understanding: The student demonstrates an advanced ability to analyze a phenomenon, identifying and interpreting all the salient elements in an exhaustive manner. The application of knowledge occurs with methodological rigor, supported by a solid and articulated argument.

Communication and argumentative skills: In the oral exam, the student develops a solid and articulated argument, with a rigorous logical structure and a high level of textual coherence. The speech is fluid and well-structured.

Learning, self-assessment and self-regulation skills: The student demonstrates an advanced ability to self-reflect, developing an articulated and in-depth analysis of his/her own learning and professional development path. The connections between formative experiences and theoretical concepts are clear, coherent and rigorous.

Office hours

15:00-17:00 Mo-Fri

Sustainable Development Goals