



UNIVERSITÀ  
DEGLI STUDI DI MILANO-BICOCCA

## COURSE SYLLABUS

### Physics I

2425-1-E2702Q003

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#### Aims

The course provides the basic notions of classical mechanics for the material point, rigid bodies, fluids and mechanical waves. Furthermore, the course trains the students to apply the acquired theoretical knowledge to the solution of real world problems. In particular, it teaches the abstraction process necessary for the modeling of the investigated system and its conversion into mathematical relations.

At the end of the course the student knows the fundamental laws that govern classical mechanics as well as their meaning and scope of application (*Knowledge and understanding*). Furthermore the student is able to apply the acquired knowledge in the modeling, analysis and solution of practical problems of classical mechanics (*Applying knowledge and understanding*) and is able to identify the most suitable method to deal with the different types of problems (*Making judgments*). During the course the student also acquires an adequate scientific language that allows him to communicate the concepts learned in a rigorous and appropriate way (*Communication skills*). Finally, at the end of the course the student recognizes the importance of a quantitative and rigorous description of the physical quantities and the formal description of their relationships, thus acquiring a fundamental scientific approach to tackle the study of all scientific disciplines (*Learning skills*) .

#### Contents

1. Physics and measurement
2. Vectors
3. Motion in one dimension
4. Motion in two and three dimensions
5. The laws of motion
6. Circular motion and other applications of Newton's laws
7. Energy of a system
8. Conservation of energy
9. Linear momentum and collisions

10. Rotation of a rigid object about a fixed axis
11. Angular momentum
12. Static equilibrium and elasticity
13. Universal gravitation
14. Fluid mechanics
15. Oscillatory motion
16. Wave motion

## **Detailed program**

### **PART I**

#### **1. Physics and measurement**

- Standards of length, mass, and time
- Matter and model building
- Dimensional analysis
- Conversion of units
- Estimates and order-of-magnitude calculations
- Significant figures

#### **2. Vectors**

- Coordinate systems
- Vector and scalar quantities
- Some properties of vectors
- Components of a vector and unit vectors

#### **2. Motion in one dimension**

- Position, velocity, and speed
- Instantaneous velocity and speed
- Particle under constant velocity
- Acceleration
- Motion diagrams
- Particle under constant acceleration
- Freely falling objects
- Kinematic equations derived from calculus

#### **4. Motion in two and three dimensions**

- The Position, velocity, and acceleration vectors
- Two- and three- dimensional motion with constant acceleration
- Projectile motion
- Particle in uniform circular motion
- Tangential and radial acceleration
- Relative velocity and relative acceleration

#### **5. The laws of motion - The laws of motion**

- The concept of force
- Newton's first law and inertial frames

- Mass
- Newton's second law
- The gravitational force and weight
- Newton's third law
- Analysis models using Newton's second law
- Forces of friction

## **6. Circular motion and other applications of Newton's laws**

- Extending the particle in uniform circular motion model
- Nonuniform circular motion
- Motion in accelerated frames
- Motion in the presence of resistive forces

## **7. Energy of a system**

- Systems and environments
- Work done by a constant force
- The scalar product of two vectors
- Work done by a varying force
- Kinetic energy and the work–kinetic energy theorem
- Potential energy of a system
- Conservative and nonconservative forces
- Relationship between conservative forces and potential energy
- Energy diagrams and equilibrium of a system

## **8. Conservation of energy**

- Non isolated system (energy)
- Isolated system (energy)
- Situations involving kinetic friction
- Changes in mechanical energy for nonconservative forces
- Power

## **9. Linear momentum and collisions**

- Linear momentum
- Isolated system (momentum)
- Nonisolated system (momentum)
- Collisions in one dimension
- Collisions in two and three dimensions
- The center of mass
- Systems of many particles
- Deformable systems
- Rocket propulsion

## **PART II**

## **10. Rotation of a rigid object about a fixed axis**

- Angular position, velocity, and acceleration
- Rigid object under constant angular acceleration
- Angular and translational quantities
- Torque
- Rigid object under a net torque

- Calculation of moments of inertia
- Rotational kinetic energy
- Energy considerations in rotational motion
- Rolling motion of a rigid object

## **11. Angular momentum**

- The vector product and torque
- Nonisolated system (angular momentum)
- Angular momentum of a rotating rigid object
- Isolated system (angular momentum)
- The motion of gyroscopes and tops

## **12. Static equilibrium and elasticity**

- Rigid object in equilibrium
- More on the center of gravity
- Examples of rigid objects in static equilibrium
- Elastic properties of solids

## **13. Universal gravitation**

- Newton's law of universal gravitation
- Free-fall acceleration and the gravitational force
- Particle in a field (gravitational)
- Kepler's laws and the motion of planets
- Gravitational potential energy
- Energy considerations in planetary and satellite motion

## **14. Fluid mechanics**

- Pressure
- Variation of pressure with depth
- Pressure measurements
- Buoyant forces and Archimedes's principle
- Fluid dynamics
- Bernoulli's equation
- Other applications of fluid dynamics

## **15. Oscillatory motion**

- Motion of an object attached to a spring
- Particle in simple harmonic motion
- Energy of the simple harmonic oscillator
- Comparing simple harmonic motion with uniform circular motion
- The pendulum
- Damped oscillations
- Forced oscillations

## **16. Wave motion**

- Propagation of a disturbance
- Traveling wave
- The speed of waves on strings
- Reflection and transmission

- Rate of energy transfer by sinusoidal waves on strings
- The linear wave equation

## Prerequisites

A good algebra and trigonometry background is required, as well as the knowledge progressively acquired in the Mathematics I lectures during the same semester, in particular, calculus (derivatives and integrals).

## Teaching form

Lectures (42 hours) and exercises (24 hours). Lectures are held in Italian.  
All lectures will be on site.

## Textbook and teaching resource

### Suggested Syllabus:

One of those listed below or at least one that covers the same topics with a similar degree of depth. During the first class, in which the course will be presented, the merits and flaws of each of the suggested textbooks will be explained.

*Young, Freedman*

University Physics with Modern Physics (15<sup>th</sup> edition)  
Pearson

*Serway, Jewett*

Physics for Scientists and Engineers (10<sup>th</sup> edition)  
Brooks/Cole Cengage Learning

\*Halliday, Resnick, Walker \*

Fundamentals of Physics – Volume One (10<sup>th</sup> edition)  
Wiley

## Semester

Both semesters

## Assessment method

The grading is based on both a written test and an oral exam. Passing the written test is required to access to the oral exam.

Two intermediate tests are also scheduled. Passing both intermediate test, allows access to the oral exam.

During the final written exam, as well as the intermediate ones, it is possible to use only a scientific calculator and a cheat sheet, as long as it is strictly handwritten by the student on a personal sheet of paper, in A4 format, provided by the teacher.

The oral exam has not to be necessarily taken at the same time as the written test. A passed written test, in fact, is considered valid until the last exam of the current academic year (i.e. until following April-May) also in case of a failed oral exam.

## Rating

The written exam aims to assess the student's ability to face specific classical mechanics problems by modeling them appropriately and resolving them quantitatively by clearly describing the logical reasoning followed and motivating the use of any formulas or principles.

The grading is reported in letters (A-F) corresponding to a numerical value (indicated between the parentheses):

- **A (34):** All 4 exercises are properly solved.
- **B (27):** Only 3 out of 4 exercises are properly solved.
- **C (20):** Only 2 out of 4 exercises are properly solved.
- **D (10):** Less than 2 exercises are properly solved but there is evidence of an appropriate knowledge of the subject.
- **E:** The test is failed and there is evidence of relevant missing notions in the subject.
- **F:** The test is badly failed with evidence of serious fundamental mistakes and an inappropriate approach in the learning activity.

The oral exam rather aims at verifying that the student has an adequate degree of understanding of the laws that govern classical mechanics, of their meaning, scope of application and possible derivation.

the score is reported with a number between 16 and 30:

- **16-20:** Knowledge limited to definitions and statements of the physical laws and principles with poor capabilities of logical interconnections between the subjects. Limited capabilities of exposition and analysis and only with the help of the teacher. Evidence of improper language and terminology.
- **21-25:** Knowledge of definitions and statements of the physical laws and principles and of their scope of validity. Good capabilities of logical interconnections between the subjects but evidences difficulties in deriving them without the help of the teacher. Proper language and terminology.
- **26-30/30L:** Complete and exhaustive preparation on the topics on the exam programme, personal capacity for autonomous treatment and critical analysis of the topics, ability for reflection and self-reflection and for connecting the topics to concrete cases and different contexts, excellent ability for critical and autonomous thinking, full mastery of the disciplinary lexicon and a rigorous and articulated expository ability, ability for argumentation, reflection and self-reflection, ability to make connections to other disciplines..

The overall evaluation, out of thirty, is obtained with a weighted average between the mark of the written test (30%) and the oral one (70%).

## Note

At the student's request, the exam can be taken in English.

## Office hours

Any day by appointment via e-mail.

**Sustainable Development Goals**

QUALITY EDUCATION

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