UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

SYLLABUS DEL CORSO

Fisica I

2122-1-E2702Q003

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

PART II

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

PART III

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

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

PART IV

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 and exercises (in Italian).

Textbook and teaching resource

Suggested Syllabus:

Serway, Jewett
Physics for Scientists and Engineers (9th edition)
Brooks/Cole Cengage Learning

Other options:

Halliday, Resnick, Walker
Fundamentals of Physics – Volume One (10th edition)
Wiley

Semester

October 2021 – January 2022

March 2022 - June 2022

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.

The written test is split into four sections, each one dealing with the concepts of the four different parts the course is split into. Each section is graded separately (A: Excellent, B: Good, C: Satisfactory, D: Unsatisfactory, E: Extremely unsatisfactory). The test is considered passed if at least three out of four parts are satisfactory, not necessarily in the same test. That is, positive outcomes in each specific section stack. Furthermore, in case in a future test the student wants to improve the grade of a specific section, only the best grade will be considered.

Four intermediate tests are also scheduled, one for each one of the four parts of the course. Passing an intermediate test, implies the passing of the respective part in the final written 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 April-May 2021) 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 oral exam aims instead to verify 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.

Note

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

Office hours

Any day by appointment via e-mail.