UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Physics I

2627-1-E2703Q004

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

PART I
Units, physical quantities, and vectors
Motion along a straight line
Motion in two or three dimensions
Newton’s laws of motion
Applying newton’s laws
Work and kinetic energy
Potential energy and energy conservation

PART II
Momentum, impulse, and collisions
Rotation of rigid bodies
Dynamics of rotational motion
Equilibrium and elasticity
Fluid mechanics
Gravitation
Periodic motion
Mechanical waves

Detailed program

PART I

1. Units, physical quantities, and vectors
The Nature of Physics
Solving Physics Problems
Standards and Units
Unit Consistency and Conversions
Uncertainty and Signi?cant Figures
Estimates and Orders of Magnitude
Vectors and Vector Addition
Components of Vectors
Unit Vectors
Products of Vectors

2. Motion along a straight line
Displacement, Time, and Average Velocity
Instantaneous Velocity
Average and Instantaneous Acceleration
Motion with Constant Acceleration
Freely Falling Bodies
Velocity and Position by Integration

3. Motion in two or three dimensions
Position and Velocity Vectors
The Acceleration Vector
Projectile Motion
Motion in a Circle
Relative Velocity

4. Newton's laws of motion
Force and Interactions
Newton's First Law
Newton's Second Law
Mass and Weight
Newton's Third Law
Free-Body Diagrams

5. Applying newton's laws
Using Newton's First Law: Particles in Equilibrium
Using Newton's Second Law: Dynamics of Particles

Frictional Forces
Dynamics of Circular Motion
The Fundamental Forces of Nature*

6. Work and kinetic energy
Work
Kinetic Energy and the Work–Energy Theorem
Work and Energy with Varying Forces
Power

7. Potential energy and energy conservation
Gravitational Potential Energy
Elastic Potential Energy
Conservative and Nonconservative Forces
Force and Potential Energy
Energy Diagrams

PART II

8. Momentum, impulse, and collisions
Momentum and Impulse
Conservation of Momentum
Momentum Conservation and Collisions
Elastic Collisions
Center of Mass
Rocket Propulsion

9. Rotation of rigid bodies
Angular Velocity and Acceleration
Rotation with Constant Angular Acceleration
Relating Linear and Angular Kinematics
Energy in Rotational Motion
Parallel-Axis Theorem
Moment-of-Inertia Calculations

10. Dynamics of rotational motion
Torque
Torque and Angular Acceleration for a Rigid Body
Rigid-Body Rotation About a Moving Axis
Work and Power in Rotational Motion
Angular Momentum
Conservation of Angular Momentum
Gyroscopes and Precession

11. Equilibrium and elasticity
Conditions for Equilibrium
Center of Gravity
Solving Rigid-Body Equilibrium Problems
Stress, Strain, and Elastic Moduli
Elasticity and Plasticity

12. Fluid mechanics
Density
Pressure in a Fluid
Buoyancy

Fluid Flow
Bernoulli's Equation
Viscosity and Turbulence

13. Gravitation
Newton's Law of Gravitation
Weight
Gravitational Potential Energy
The Motion of Satellites
Kepler's Laws and the Motion of Planets
Apparent Weight and the Earth's Rotation

14. Periodic motion
Describing Oscillation
Simple Harmonic Motion
Energy in Simple Harmonic Motion
Applications of Simple Harmonic Motion
The Simple Pendulum
The Physical Pendulum
Damped Oscillations
Forced Oscillations and Resonance

15. Mechanical waves
Types of Mechanical Waves
Periodic Waves
Mathematical Description of a Wave
Speed of a Transverse Wave
Energy in Wave Motion
Wave Interference, Boundary Conditions, and Superposition
Standing Waves on a String
Normal Modes of a String

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

Textbook and teaching resource

Suggested Syllabus:

Young, Freedman
University Physics with Modern Physics (15?? edition)
Pearson

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, iallows 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 numbers (out of 30).

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 grading is reported in numbers (out of 30).

- **16-20**: Knowledge limited to definitions and statements of the physical laws and principles with poor capabilities of logical interconnections beteween the subjects. Limited capabilities of exposition and analysis and only with the help of the teacher. Evidence if improper language and terminology.
- **21-25**: Knowledge of definitions and statements of the physical laws and principles and of theis scope of validity. Good capabilities of logical interconnections beteween the subjects but evidences dififculties 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