UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

General Physics - Mechanics and Waves

2526-1-ESM02Q001

Aims

The course aims at introducing students to the discipline of physics, in particular to the knowledge of classical mechanics. The topics are treated by accompanying theoretical explanations with numerous examples and problems, useful for a better understanding of the subjects. Extensive references to the connections between the topics covered and the topics developed in more advanced courses are also proposed.

Learning outcomes expressed through the five Dublin Descriptors:

1. Knowledge and understanding
   By the end of the course the student will be able to:

- Define the fundamental concepts of kinematics and dynamics for a point particle (position, velocity, acceleration vectors; Newton's laws).
- Explain the conservation principles of mechanical energy, linear momentum and angular momentum, distinguishing between conservative and non-conservative forces.
- Describe the dynamics of systems of particles, rigid bodies and non-inertial reference frames, including the origin of fictitious forces.
- Illustrate the properties of central force fields and the law of universal gravitation.
- Discuss the kinematics and dynamics of ideal and real fluids, as well as mechanical oscillations (free, damped, forced) and the propagation of mechanical waves in different media.

2. Applying knowledge and understanding
   The student will be able to:

- Solve quantitative problems in kinematics, dynamics and collisions (elastic and inelastic) using vector algebra and conservation laws.
- Analyse the energetic behaviour of systems subject to conservative forces and to dissipative forces (kinetic and viscous friction).
- Model mechanical oscillators (single-degree-of-freedom or two-body coupled systems) and predict their

damped and forced responses.
- Calculate key parameters of longitudinal and transverse waves (phase velocity, wavelength, frequency) and determine conditions for interference and standing waves.

3. Making judgements
   The course will develop the ability to:

- Assess the validity of assumptions and approximations in mechanical and fluid-dynamic models, deciding when to use point-mass, rigid-body or continuum descriptions.
- Estimate critically measurement errors and uncertainties in numerical results from exercises and experimental problems.
- Select the most convenient reference frame (inertial, co-moving, rotating) to simplify the analysis of a given problem.

4. Communication skills
   On completion of the course students will be able to:

- Present solutions to complex problems with logical structure, correct notation and explanatory graphs.
- Write reports that connect theoretical concepts to practical examples (e.g. engineering or biomedical fluid dynamics).
- Collaborate in small groups to solve exercises, clearly arguing methods and results.

5. Learning skills
   The course will enable students to:

- Relate the content of classical mechanics to topics in subsequent courses (thermodynamics, electromagnetism, modern physics).
- Consult independently scientific textbooks and online resources to deepen topics such as chaotic motion, advanced fluid mechanics or complex wave phenomena.
- Transfer acquired problem-solving methods (dimensional analysis, linearisation, use of generalized coordinates) to interdisciplinary contexts in engineering, applied sciences and technology.

Contents

Classical mechanics

Detailed program

Algebra of vectors

Kinematics of a material point

Dynamics of a material point

Mechanical work and kinetic energy

Conservative forces

Potential energy; mechanical energy and its conservation

Non conservative forces; sliding and viscous friction

Inertial and non inertial reference systems; Galileian principle of relativity; fictitious forces

Dynamics of points systems

Collisions between material points

Dynamics of rigid bodies

Properties of a central force field

Universal gravitation

Kinematics and dynamics of fluids

Free, damped, and forced oscillations; two-body oscillator

Propagating and standing mechanical waves

Prerequisites

Knowledge of algebra and analysis (program of the first math course)

Teaching form

The course is held in delivery mode and in Italian; consists of lectures (56 hours) and exercises (24 hours).

Textbook and teaching resource

Halliday D, Resnik R, Fondamenti di fisica, CEA (Casa Editrice Ambrosiana)
P. Mazzoldi, M. Nigro, C. Voci, "Elementi di Fisica vol. 1 - Meccanica e Termodinamica" EdiSES

Semester

First and Second semester (December-May)

Assessment method

The exam includes a written test, followed by an oral test.

The two-and-a-half-hour written test involves solving five problems related to course topics. Solving at least three of the five problems correctly is considered sufficient.
The subsequent oral test consists of an interview about some of the course topics and a discussion of any problems the student did not correctly solve on the written test.
The oral exam may be taken during the same session as the written exam or during one of the two subsequent sessions.

Office hours

Appointments can be made via email.

Sustainable Development Goals

QUALITY EDUCATION