UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Mechanics

2627-1-E3004Q003-E3004Q00301

Aims

This course will develop a conceptual frame to understand the fundamentals of mechanics by explaining the core concepts, describing the experimental verification of our theoretical laws, and showing how to apply the theoretical framework to describe and predict the motions of bodies.
Students will develop a deep understanding of the fundamental laws governing motion and forces, learn to analyse complex mechanical systems, and gain proficiency in problem-solving techniques essential for advanced physics. Emphasis will be placed on both theoretical foundations and practical applications. Upon successful completion of this course, students will be able to:
• Apply theoretical laws to solve problems involving particles and rigid bodies.
• Understand and utilize concepts of work, energy, and momentum, including conservation laws.
• Understand the principles of rigid body dynamics.
• Apply classical mechanics principles to various physical systems.

Learning outcomes:
DdD1 Knowledge and understanding – Students will acquire a deep knowledge of the mechanics laws and of theoretical framework, comprised the mathematical instrument needed for the description of the topics
DdD2 Applying knowledge and understanding – Students will be able to solve exercises and problems using the theoretical knowledge and the practical examples learned.
DdD3 Making judgments – Through the guided resolution of problems and exercises, students will develop the ability of choosing the best strategies and the adequate mathematical instruments to find the solution of new problems.
DdD5 Learning skills - The mixed didactic organization requires the students to use multimedia, develop autonomous study and adaptivity, managing time, materials and exercises. This will enhance the ability to learn more advanced topics after the course.

Contents

• Basics and mathematical instruments
• Kinematics
• Dynamics
• Energy
• Relative motion
• Point systems
• Gravity
• Rigid Body

Detailed program

Review of physical quantities, units of measurement, vectors, vector calculus. Cartesian, intrinsic, polar (spherical) coordinate systems. Material point. Physical system. Kinematics of the point mass in 1D, 2D, 3D: position vector, velocity, acceleration, rectilinear motion, uniform, uniformly accelerated, simple harmonic, circular, uniform circular, curvilinear, parabolic, varied motion.

Forces/interactions, classification of forces, resultant. Principle of superposition. The 3 principles of dynamics. Ideal and real constraints, constraining reactions. Momentum, impulse. Weight force, sliding and viscous friction force, elastic force, centripetal forces. Inclined plane. Simple pendulum. Wire tension.

Work, power, energy. Kinetic energy, potential energy, conservative forces. Conservation of energy. Theorem of Kinetic energy. Conservation of mechanical energy. Torque, angular momentum. Central forces.

Relative motions: reference frames, relative velocities and acceleration. Drag acceleration, Coriolis, centrifuge. Apparent forces and the second law of dynamics in relative systems. Galilean relativity. Smooth and accelerated straight drag motion. Uniform rotary drive motion. Relative motions on Earth. The motion of the Earth.

Point systems, internal and external forces. Center of mass. Theorem of the motion of the center of mass. Conservation of momentum. Angular momentum theorem. Spin. Conservation of angular momentum. Reference system of the center of mass. König's theorems and kinetic energy theorem. Collisions between two material points. Fully inelastic and fully elastic collisions. Partially inelastic impact. Variable mass.

Kepler's laws. Gravitational interaction. Inertial mass and gravitational mass. Gravitational potential energy. Gravitational field and gravitational potential. Gauss' theorem and applications. Escape speed. Orbital velocity. Equation of orbits. Free fall. Motions of the Earth. Definition of rigid body. Degrees of freedom.

Motion of a rigid body: translational, rotational, roto translational. Continuous body, center of mass. Rotation of the rigid body around a fixed axis, moment of inertia, effect of transverse angular momentum. Huygens-Steiner theorem. Composed pendulum. Pure rolling motion, with/without force/moment. Angular impulse, moment of impulse. Poinsot's theorem, ellipsoid of inertia. Gyroscopes. Free rigid body. Laws of conservation of motion of a rigid body. Collisions between material points and rigid bodies. Rigid body statics.

Prerequisites

Basics of calculus (differential equations, vector calculus) - Introductory Physics (basics of Newtonian mechanics concepts)

Teaching form

The teaching mode is mixed: after a presential introductory lesson, most of the theoretical lessons will be in asynchronous recorded form. At the end of each chapter there will be an appointment to discuss the highlights of the block of lessons. 12 hours of exercise resolution will be delivered in presence.

Textbook and teaching resource

Materials given by the chair of the course: slide, documents
Suggested books

- Alessandro Bettini - A Course in Classical Physics 1— Mechanics
- Eric Mazur - PrInCIPleS & PrACTICe of PhySICS
- Principles of physics, David Halliday; Robert Resnick; Jearl Walker

Semester

First semester

Assessment method

The assessment relies on a written essay consisting of PROBLEMS (questions that require the analysis of a complex phenomenon and its rationalization through the composition of several principles) and EXERCISES (answers to simple questions that require the application of specific principles or techniques). During the examination, the instructor evaluates the student's learning level and the communication capabilities pertaining to the specific field of mechanics. There will be no intermediate tests. If the written exam is passed, the oral can be taken; it consists in theorical questions on topics explained in the course.

Office hours

The chair of the course is available to receive students upon request by email.

Sustainable Development Goals

QUALITY EDUCATION