UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Physics

2122-2-E3101Q130

Aims

The course is an introduction to the main topics of Classical Physics and to the exploitation of the scientific method. The course aims to provide the knowledge and tools for the understanding of simple natural phenomena observable in everyday life and for the solution of simple problems of Classical Physics .

Contents

- Classical Mechanics
  - Kinematics
  - Dynamics
  - Work and Energy
  - harmonic motion and oscillations
- Gravitation
- Fluids
- Thermodynamics
- Electromagnetism
  - Electrostatics
  - circuits
  - Magnetism
  - Electromagnetism

Detailed program

Introduction

- Measurements, units
- Significant figures and orders of magnitude
- Vectors and scalars

Kinematics

- point-like particle motion
- velocity (average and instantaneous) and speed in one dimension
- integral of velocity over time
- 1D motion with constant velocity
- average and instantaneus acceleration
- 1D motion with constant acceleration
- equations of motion with costant acceleration
- free fall
- Cartesian and polar coordinates
- kinematics in 2 or 3 dimensions
- uniform circular motion: centripetal acceleration, harmonic motion
- motion in 2 dimensions. circular motion at variable velocity. tangential acceleration

Dynamics

- Reference frames. Galileo's transformations. Inertial reference frames
- The concept of force (examples)
- Galileo experiments
- Newton's 1st principle
- Mass and inertia
- Newton's 2nd principle
- Newton's 3rd principle
- Examples of forces (field forces, contact forces, spring, apparent forces)
- Normal force, tension, friction

Energy and Work

- Work (constant force, 1D)
- Scalar product of vectors
- Work (variable force)
- Work (variable force, 3D)
- Kinetic energy theorem
- Spring-mass system with and without friction
- Conservative force
- Potential energy
- Examples of conservative forces (spring, weight) and corresponding potential energies
- Mechanical energy conservation
- Work performed from the outside on a system with or without non-conservative forces
- Energy conservation
- Energy diagrams

Gravitation

- Universal gravitation: Tycho Brae, Kepler, Galileo and Newton
- The three laws of Kepler
- Newton's Law of Gravitation
- Cavendish experiment (measurement of G and earth mass)
- Gravitational field
- Spherical shell with spherical symmetry
- Acceleration of gravity on the surface of the earth
- Circular orbit and Kepler's third law
- Gravitational potential energy
- Energy diagrams: total energy for a circular orbit
- Gravity inside the earth

Harmonic motion and oscillations

- Harmonic motion
- Oscillations: mass-spring system
- Simple pendulum *
- Gravity inside the earth *

Fluid Mechanics

- Fluids: liquids and gases
- Density and pressure
- Fluids at rest
    - Stevino's law: hydrostatic pressure, atmospheric pressure
    - Pressure measurement: Torricelli barometer and differential pressure gauge
    - Pascal's principle
    - Hydraulic press or hydraulic lever
    - Archimedes's Principle of (buoyancy and apparent weight)
    - Verification of Archimedes's principle
- Ideal fluid in motion
    - Streamlines and tube of flow
    - Continuity equation
    - Applications of the eq. continuity: tap flow
    - Bernoulli's theorem (energetic considerations)
    - Applications of the Bernoulli Theorem: Torricelli's law

Thermodynamics

- Properties of matter: microscopic and macroscopic description
- Thermodynamics vs. Statistical mechanics
- Introduction to thermodynamics
- Thermodynamic system
- Thermodynamic variables
- Thermodynamic equilibrium - Thermal equilibrium
- Temperature and zeroth law of thermodynamics
- Thermometry: Celsius scale, Absolute scale
- Gas thermometer

- Ideal gases
    - Boyle's law
    - Avogadro's law: mole, molar mass, molecular mass
    - Ideal Gas Law
    - Kelvin scale
    - Constant volume gas thermometer
- Kinetic Theory of Gases: pressure, temperature, internal energy and ideal gas law
- Temperature - Heat - Work - Internal energy
- Equivalence Heat - Work
- Thermal capacity and latent heat *
- Thermal expansion *
- Thermodynamic equilibrium transformations
- First law of thermodynamics
- Work and thermal capacity of a perfect gas

Electrostatics and circuits

- Introduction: charges, induced charges, insulators and conductors
- Coulomb's law
- Electrostatic field, electrostatic field lines
- Flux of the electrostatic field
- Gauss's law
- Applications of the Gauss's law:
    - Point charge
    - Spherical charge distribution *
    - Infinitely long charged wire *
    - Planar distribution
- Electric field of conductors
- Electric potential, equipotential surfaces
- Potential due to a point charge and to a spherical distribution
- Electric field from the electric potential
- Potential of conductors
- Electric capacitance, capacitors, parallel plate capacitor
- Series and parallel capacitors *
- Current and circuits
    - Resistance and Ohm's law
    - Resistors in series and in parallel *
    - Kirchoff's laws *
    - RC circuits *

Magnetism

- Static magnetic fields: force on moving charge, field lines, Lorentz force
- Electric current carrying wire in magnetic field
- Motion of a charge in magnetic field *
- Magnetic field generation:
    - Biot-Savart law
    - Magnetic field generated by infinitely long current-carrying wire
    - Magnetic field generated by current loop in the center and in the loop plane
- Ampere's law
- Application of the Ampere's Law to the infinite wire and to the solenoid
- Force between 2 parallel currents
- Maxwell equations for static fields in vacuum

- Electromotive force: electrostatic field and electric field
- Faraday experiment and magnetic induction
- Magnetic field flow
- Faraday's law and Lenz's law
- Maxwell equations in vacuum

Prerequisites

The basic concepts learnt at Calculus classes.

Teaching form

- Lessons (**6 CFU** / 48 hours)
- Exercise classes (**2 CFU** / 20 hours)

The course is delivered in Italian, or in english when needed.

All lessons will be video-recorded and made available on the e-learning platform at https://elearning.unimib.it

Textbook and teaching resource

In general, any textbook of Physics (Mechanics, Thermodynamics and Electromagnetism) at university level for scientific or engineering faculties is suitable, for example

- D. Halliday, R. Resnick. *Fundamentals of Physics*, Wiley
- R. Serway, J. Jewett. *Physics For Scientists And Engineers,* Brooks/Cole

Semester

Second year, first semester.

Assessment method

- **Written exam:** exercises to solve and questions on theory,

- **Oral exam:** when required.

There are 5 exam sessions: January, February, June, July and September.

The written tests passed with at least 18/30 are valid to complete the exam. Students can ask for an oral, and oral is required for honors. The oral exam can be carried out in English.

Office hours

Anytime, on appointment by email.