



UNIVERSITÀ  
DEGLI STUDI DI MILANO-BICOCCA

## COURSE SYLLABUS

### Physics

2122-2-E3101Q130

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#### 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
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  - 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 instantaneous acceleration
- 1D motion with constant acceleration
- equations of motion with constant 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.

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## **Office hours**

Anytime, on appointment by email.

