MEDTEC SHOOL

Course: Fundamentals of experimental physics

Year: 1st

Period: 1st semester

Credits: 10

Objectives

The course of Experimental Physics has the main objective to give the student the understanding of the fundamental principles of natural phenomena, scientific and engineering methods.

In particular, the course aims to:

- introduce the student to the experimental method, which constitutes a fundamental investigative tool not only in physics, but for every scientific discipline, including engineering and medicine;

- teach the fundamental elements of mechanics and electromagnetism, showing the universality of the laws of physics and their applications;

- teach the student how to describe a physical phenomenon in a quantitative way, with adequate mathematical formalism.

Prerequisites

Good knowledge of high school mathematics, including use of vectors and derivatives.

Contents

1. INTRODUCTION TO PHYSICS

The experimental method. Physical quantities and their measurement. The International System of units. Vectors and unit vectors. Dot and cross product.

2. KINEMATICS

Frames of reference. Scalar kinematics. Uniform and accelerated motions. Position, velocity and acceleration vectors. Normal and tangential components of acceleration. Straight, circular and parabolic motions.

3. DYNAMICS OF POINT OBJECTS

Principles of Newtonian dynamics. Gravitational and weight forces. Reactions and friction. Motion along inclined planes. Ropes and pulleys. Elastic force. Speed-dependent forces: flow resistance.

4. WORK AND ENERGY

Work of a force. Kinetic energy and work-energy theorem. Conservative forces and potential energy. Conservation of mechanical energy. Non-conservative forces.

5. SYSTEMS DYNAMICS

Particle systems: the center of mass. Cardinal equations of dynamics: motion of the center of mass. Conservation of momentum and angular momentum. Impact phenomena and impulse of a force. Rotation of rigid bodies and precession (hints).

6. GASES AND FLUIDS

Pressure, temperature, moles. Microscopic interpretation of temperature and pressure. Kinematic theory of gases (hints of thermodynamics). Static equation of perfect fluids. Archimede's principle. Ideal fluids in motion. Continuity equation. Hints of fluid dynamics and Bernoulli principle.

7. VIBRATIONS AND WAVES

Harmonic oscillator and motion of a pendulum. Dumped and forced oscillations. Resonance. Waves in a vibrating strings. Sound waves. Interference of waves (hints).

8. ELECTROSTATICS FIELD AND GAUSS THEOREM

The Coulomb's law. Definition of electric field. The principle of superposition. The electric field generated by discrete and continuous charge distributions. Flow of the electric field. The Gauss theorem in integral form.

9. ELECTROSTATIC POTENTIAL

The work of the electric force. The potential energy of the electrostatic force. The electrostatic potential.

10. CONDUCTORS, CAPACITORS AND DIELECTRICS

Conductor properties. Electrostatic screen and the Faraday's cage. Capacity of an insulated conductor. The condenser. Phenomenological and microscopic aspects of polarization of dielectric materials.

11. CURRENTS AND CIRCUITS

Microscopic description of conductors and insulators, conduction bands and band gap. Ohm's law and microscopic description of the current in a conductor. Electromotive force and generators. Examples of electric circuits.

12. MAGNETOSTATICS

Phenomenology of the magnetic field. The Lorentz force and applications in charge rotation and acceleration. The properties of the static magnetic field. Laplace's laws. Ampère's law for the circulation of the magnetic field. Forces between circuits crossed by currents. Magnetic dipoles. Principles of magnetic resonance.

13. ELECTROMAGNETIC INDUCTION

Faraday's law for electromagnetic induction. Induction and inductors.

14. MAXWELL'S EQUATIONS AND ELECTROMAGNETIC WAVES

The displacement current. Maxwell's equations in the integral form. Electromagnetic waves (hints).

Teaching Methods

The course consists of lectures and exercise classes at the blackboard. Two multidisciplinary activities are planned at the end of the course, one related to electrical signal propagation in biological systems (conducted together with the course of Physiology), the other related to the topic of resonance (conducted together with the course of Mathematics).

Verification of learning

The exam consists in a written test covering the whole program (both open theory questions and numerical exercises). The exam may be taken in January (one test), February (one test), July (two tests) or September (one test). The students may take an optional oral exam, for written evaluations starting from 18/30.

Texts

Young & Freedman, University Physics with Modern Physics, Publisher: Pearson