MEDTEC SCHOOL

Course: Fundamentals of experimental physics

Year: 1st

Period: 1st semester

Credits: 10

Objectives

The course in Experimental Physics has the main objective of giving students an 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.

Expected learning outcomes

DD1 (Knowledge and understanding):

The student will gain knowledge on the main physical quantities used to represent the elementary phenomena in mechanics and electromagnetism, their definition and their respective units of measurement in the International System.

The student will gain knowledge on the physical principles of Mechanics and Electromagnetism and will show that they have full understanding of the experimental laws that describe them and the limits of these descriptions.

DD2 (Applying knowledge and understanding):

The student will have an understanding of the links between the physical quantities that describe a natural phenomenon and will be able to represent them through mathematical formalism.

The student will be able to determine the evolution of physical phenomena on a spatial and/or temporal scale by solving the equations that govern it and critically analysing the results obtained in relation to their physical meaning.

Prerequisites

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

Content

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.

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. 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.

8. ELECTROSTATIC POTENTIAL

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

9. CONDUCTORS, CAPACITORS AND DIELECTRICS

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

10. 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.

11. 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 in which current flows. Magnetic dipoles.

12. ELECTROMAGNETIC INDUCTION

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

13. MAXWELL'S EQUATIONS AND ELECTROMAGNETIC WAVES

The displacement current. Maxwell's equations in the integral form.

UN sustainable development goals (SDGs)

The course contributes to the UN SDG9 - INDUSTRY, INNOVATION AND INFRASTRUCTURE

Teaching Methods

The course consists of lectures and exercise classes taught in person on the blackboard.

Verification of learning

The exam consists of a written test and an optional oral test (only for those eligible, based on their written test mark) covering the entire course program. The written test consists of 3-4 numerical exercises.
The exam may be taken in January-February (two separate tests), June-July (two tests) or September (one test).

Textbook

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

https://www.pearson.com/us/higher-education/program/Young-University-Physics-with-Modern-Physics-Plus-Mastering-Physics-with-Pearson-e-Text-Access-Card-Package-15th-Edition/PGM2485469.html