UNIVERSIDAD DE GRANADA

Facultad de Ciencias
Sección de Físicas

FACULTY OF SCIENCE. UNIVERSITY OF GRANADA

PHYSICS DEGREE

STANDARD TIME FOR COMPLETING COURSE

8 semesters (4 years)

START OF STUDY

September (Winter semester)

COURSE STRUCTURE

In total 240 ECTS credit points are required.

Mandatory elective modules: 180 ECTS including Batchelor's thesis, 6 ECTS

General elective modules: 60 ECTS credit points

One credit point (ECTS) equals a workload of 25 - 30 hours for preparation, follow-up and attendance at classes.

COURSE OBJECTIVES

Physics is a fundamental Science essential for the scientific and technologic development of any country. The study in Physics are not only useful for students particularly interested in fundamental research, but also it provides a very wide and versatile formation useful for many other types of job positions. The main objectives sought during the learning process are:

To develop capacity of observation and classification of natural phenomena using the knowledge acquired from the different branches of Physics.

To acquire a general knowledge about the main issues of Physics, covering both theory and experiments.

To achieve the capacity of applying the acquired knowledge to the professional environment. Capacity of presenting and discuss ideas in the context of Physics.

To be able to gather information about some subject of interest, to analyze it and provide a reasoned judgement.

To be able to analyze problems in different fields, to extract the most relevant information and propose a solution to it, applying the main mathematical and computational techniques.

To be able to continue postgraduate studies in several scientific or technological topics. In addition, the student should acquire the capacity of adapt him/herself to the occupational requirements not directly connected to Physics.

To develop entrepreneurial skills supported by the acquired knowledge in fundamental science, topics of interest (such as environment science, energy source, etc) and in the contact with business world by means of external practices.

COURSE CONTENT

All information about the current timetable may be obtained online at http://grados.ugr.es/fisica/pages/infoacademica/guiasdocentes20152016.

FIRST YEAR

FIRST SEMESTER

GENERAL PHYSICS I 6 ECTS

Newton dynamics. Rigid solid dynamics. Gravity. Solids and Fluids. Harmonic oscillator. Introduction to waves. Wave superposition. Temperature. First and second principles of Thermodynamics

CALCULUS I 6 ECTS

Real and complex numbers. Successions and series. One variable functions. Limits and continuity. Differential calculus. Integral calculus

LINEAR ALGEBRA AND GEOMETRY I 6 ECTS

The mathematical language. Set theory. Vector space. Matrixes and linear equations. Linear applications. Eigenvalues and eigenvectors.

GENERAL CHEMISTRY 6 ECTS

Chemical bod. Intermolecular forces. States of matter. Solutions. General aspects on chemical reactions. Acid-base reactions. Redox reactions. Solubility of ionic compounds. Organic chemistry. Laboratory practices.

COMPUTER PROGRAMMING 6 ECTS

Operative systems. Main programing languages. Fundamentals in programming. Advanced programming: objects. Scientific informatics libraries. Applications to scientific problems.

SECOND SEMESTER

GENERAL PHYSICS II 6 ECTS

Introduction to electrostatic and magnetostatic fields. Dielectrics and conductors.. Introduction to electromagnetic induction and Maxwell equations. Light and electromagnetic waves. Geometrical optics. Introduction to quantum mechanics.

CALCULUS II 6 ECTS

Metric and topology of the Euclidean space. Functions of several variables: limit and continuity, differentiation and integration. Polar, spherical and cylindrical coordinates. Line and surface integrals. Green, Gauss and Stokes theorems. Application to Fluid Mechanics.

LINEAR ALGEBRA AND GEOMETRY II 6 ECTS

Multilineal applications and tensors. Euclidean vector space. Euclidean affine space. Conics and quadrics.

NUMERICAL METHODS AND SIMULATIONS 6 ECTS

Computer arithmetic. Interpolation and approximation of functions. Numeric differentiation and integration. Solution of linear algebraic equations. Searching zeros of functions. Numerical resolution of differential equations: Taylor and Runge-Kutta methods.

EXPERIMENTAL TECHNIQUES 6 ECTS

The scientific method. Experimental errors. Analysis, interpretation and presentation of experimental results. Instrumentation. Introduction to Dimensional Analysis. Elements of Descriptive Statistics. Probability distributions. Estimation of parameters. Laboratory practices: Kater pendulum, torsion pendulum, radioactivity, determination of solid and liquid densities, measurement of viscosity using the Stokes method, calorimetry, specific heat of solids, heat of fusion of ice, use of oscilloscope, velocity of sound, lens and systems of lens, Fraunhofer diffraction, circuits of alternating current.

SECOND YEAR

FIRST SEMESTER

THERMODYNAMICS (**annual**) 12 ECTS

Definitions: thermodynamic systems, equilibrium, process, work. Principles 0, 1 and 2 of Thermodynamics. Thermodynamic potentials and their derivatives. Massieu functions. Conditions of equilibrium and stability. Principles of maximum entropy and minimum energy. Clausius and Gibbs inequalities. Phases in equilibrium: First and second order transitions. Critical points. Third principle. Introduction to irreversible processes. Laboratory practices.

CLASSICAL MECHANICS ANS WAVES (**annual**) 12 ECTS

Introduction to field theory. Newtonian mechanics: particle and systems. Oscillations: Harmonic motion and non-linear oscillations. Fundamentals of Analytical Mechanics: Lagrangian and Hamiltonian formulations; applications. Waves and transport. Mechanics of deformable systems: elastic solids and fluids. Introduction to Special Relativity. Laboratory practices.

MATHEMATICAL METHODS I 6 ECTS

Complex numbers and topology of the complex plane. Complex variables. Cauchy theorem and its applications. Series in the complex plane. Singularities. Residue theorem and its applications. Fourier series. Fourier and Laplace transforms: Application to the resolution of ordinary differential equations.

MATHEMATICAL METHODS II 6 ECTS

Resolution of first and higher order differential equations. Special functions: elementary, hypergeometric and Bessel functions. Resolution of partial differential equations. Application to the Laplace equation, equation of heat and wave equation. Introduction to Sturm-Liouville problems.

ELECTRICAL CIRCUITS: THEORY AND INSTRUMENTATION 6 ECTS

Variables and elements of electrical circuits. Laws, analysis methods of solution in resistive circuits. The operational amplifier. Fourier series and transforms: fasors and Bode diagram. Frequency-domain circuit response. Laplace equations: impedance and transference functions. Time-domain circuit response. Transmission lines. Power and inductance phenomena.

SECOND SEMESTER

MATHEMATICAL METHODS III 6 ECTS

Normed and Banach spaces. Euclidean and Hilbert spaces. Functional spaces and series expansions. Functionals and distributions. Linear operators. Introduction to spectral theory.

ELECTIVE MODULE 1 ([1]) 6 ECTS

ELECTIVE MODULE 2 ([1]) 6 ECTS

([1]) Elective modules 1 and 2 must be chosen from among the following three options:

FUNDAMENTAL ASTROPHYSICS 6 ECTS

History of Astronomy and general techniques. Kepler Laws. Solar system: planets, satellites, asteroids and comets. Formation of the Solar system. Stars: structure, observations and stellar evolution. Galaxies: the Milky Way, Hubble classification, formation and evolution. Cosmology. Evolution of the Universe. Practical exercises.

ENVIRONMENTAL PHYSICS 6 ECTS

Contamination and sustainable development. Urban contamination. Physical contamination. The energetic problem. Energy obtained from non-renewable resources: energetic centrals, exergy, inefficiencies, waste heat and storage of energy. Renewal energies. Nuclear energy: residue management and control. Acoustic, electromagnetic and light pollution. Air pollution.

PHYSICS OF THE ATMOSPHERE 6 ECTS

Composition and structure of the Earth's atmosphere. Atmospheric radiation. Atmospheric thermodynamics. Atmospheric stability. Condensation, cloud formation and precipitation. Atmosphere dynamics. Conservation laws. Geostrophic approximation. Thermal wind. Circulation. Vorticity and divergence. Frontal storms at mid-latitude.

THIRD YEAR

FIRST SEMESTER

ELECTROMAGNETISM (**annual**) 12 ECTS

Electrostatics. Magnetostatics. Faraday law. Inductance. Maxwell equations in vacuum. Multipolar expansion. Electric field and matter: electric polarization, dielectrics and displacement current. Magnetic field and matter: magnetization, Ampere law for material mediums. Maxwell equations in material mediums. Electromagnetic waves. Laboratory practices.

QUANTUM PHYSICS (**annual**) 12 ECTS

Origins of quantum mechanics. The wave function and the Schrödinger equation. Application to solve one-dimensional problems. Angular momentum. Tridimensional problems: free particle, square wells, harmonic

oscillator, particles interacting through a radial potential, the hydrogen atom. An introduction to perturbation theory and variational method. Laboratory practices.

OPTICS I 6 ECTS

Fundamentals of geometric optics. Paraxial optics. Optical systems. Optical aberrations. Fundamentals of wave optics. Theory of polarization. Reflection and refraction in dielectrics. Optics in metallic mediums. Propagation of light through anisotropic media. Optics in crystals. Polarized light. Interference phenomena. Coherence of light. Laboratory practices.

ELECTIVE MODULE 3 ([2]) 6 ECTS

ELECTIVE MODULE 4 ([2]) 6 ECTS

SECOND SEMESTER

STATISTICAL PHYSICS 6 ECTS

Introduction: systems with many particles. Microscopic description. Postulates of Statistical Physics. Ensembles: microcanonical, canonical and grand canonical. Classical ideal systems. Thermodynamic limit and fluctuations. Critical opalescence. Equivalence between ensembles. Gas of atoms and molecules. Quantum ideal gases. Fermi-Dirac statistics: for highly degenerated fermion gases. Electronic gas in metals. Bose-Einstein statistics for highly degenerated boson gases. Bose-Einstein condensation. Photons and phonons. Magnetic systems.

OPTICS II 6 ECTS

Coherence of light. Diffraction. Fourier optics Classical model of light-matter interaction. Introduction to non lineal optics. LED and lasers. Optical fiber and waveguides

ELECTIVE MODULE 5 ([3]) 6 ECTS

([2]) Elective modules 3 and 4 must be chosen from among the following four options:

ANALYTICAL MECHANICS. CONTINUUM MEDIA 6 ECTS

Introduction and fundamental concepts: D'Alembert principle. Lagrangian and Hamiltonian formulation. Hamilton-Jacobi theory. Fundamental concepts mechanics of continuum media. Motion and deformation. Motion laws in mechanics of continuum media. Constitutive equations of the linear elastic solid, ideal fluid and viscous fluid.

GEOPHYSICS 6 ECTS

Structure and composition of the Earth. Gravimetry. Seismology. Geomagnetism. Geoelectricity. Geothermal energy, radioactivity and Geochronology. Geodynamics.

BIOPHYSICS 6 ECTS

Introduction to thermodynamics of irreversible processes. Time and space ordering: irreversible processes far from equilibrium. Oscillatory behavior in biological systems. Diffusion and reaction. Chaos in biological systems. Biophysics of membrane potentials. Passive transport through membranes. Facilitated transport. Ionic channels. Active transport. Effect of chemical reactions on transport processes. Introduction to molecular biophysics. Genetic material. Laboratory practices.

MATHEMATICAL PHYSICS 6 ECTS

Linear operators in Hilbert spaces. Tensorial product of Hilbert spaces. Symmetries in physics. Representations of a symmetry group. Continuum groups. Monte Carlo methods: fundamentals and applications.

([3]) Elective module 5 must be chosen between the following two options:

COMPUTATIONAL PHYSICS 6 ECTS

The computer as a tool for research in Physics. Fundamental tools: Linux and Fortran. Numerical resolution of differential equations. Molecular Dynamics: Verlet algorithm. Application to the formation and evolution of the Solar system. Monte Carlo methods and stochastic processes. Percolation and phase transitions. Resolution of partial differential equations. Finite element methods. Systems of coupled differential equations: Runge-Kutta algorithm. Application to the motion of a special ship. Resolution of integral equations. Application to the static distribution of charge in a conductor.

RADIOACTIVITY AND ITS APPLICATIONS 6 ECTS

Historical aspects of radioactivity. Structure of atoms: atomic radiation. Structure of atomic nucleus: Alpha. Beta and gamma disintegrations. Nuclear fission. Sources of natural and artificial radiation. Sources of neutrons. Laws of disintegration. Interaction matter-radiation Radiation detectors. Dosimetry. Applications in medicine. Laboratory practices.

FOURTH YEAR

FIRST SEMESTER

QUANTUM MECHANICS 6 ECTS

Experiment of Stern-Gerlach. Postulates of quantum mechanics. Schrödinger equation. Quantization rules. Superselection rules. Heisenberg representation. The wave function: position and momentum representations. Ehrenfest theorem. The Feynman path integral. Angular momentum: spin and orbital momentum. Spherical Harmonics. Composition of angular momenta. Theorem of Wigner-Eckart. Discrete and group symmetries. Systems of identical particles. Theory of collisions. Methods of approximation.

NUCLEAR AND PARTICLE PHYSICS 6 ECTS

General properties of atomic nucleus. Nuclear disintegration. Nuclear forces. Deuteron and nucleon-nucleon collisions. Nuclear models. Introduction to particle physics. Kinematic relativity. Symmetries. Conservation laws. Quarks. Hadrons spectroscopy.

SOLID STATE PHYSICS 6 ECTS

Crystalline structure of solids. Brillouin zones. Bragg equation. Scattering of a real crystal: form and structure factor. Fonons: thermal properties of solids. Acoustic and optic branches. Inelastic scattering of neutrons and electromagnetic radiation. Specific heat: Debye theory. Free electrons in metals. Band theory of solids: metals, semiconductors and non-conductors. Transport phenomena in solids. Superconductivity: Ginzburg-Landau and BCS theories. High-temperature superconductors. Magnetism in solids. Laboratory practices.

ELECTIVE MODULE 6 ([4]) 6 ECTS

ELECTIVE MODULE 7 ([4]) 6 ECTS

SECOND SEMESTER

ELECTRONICAL PHYSICS 6 ECTS

General review of band theory in solids. Concentration of electrons and holes in semiconductors. Transport of charge in semiconductors. Generation and recombination of carriers. Diffusion processes in semiconductors. The P-N union. Semiconductor devices.

BACHELOR THESIS 6 ECTS

The Bachelor thesis must be understood as a comprehensive module, oriented to the evaluation of the competences acquired during the degree. The main objective is to prepare a supervised activity in which the student applies these competences. The Bachelor thesis also provides a method of evaluation of the general formation in Physics and in the preparation for the professional world. In addition to the written memory, the student has to present his/her Bachelor thesis to the evaluation committee

ELECTIVE MODULE 8 ([5]) 6 ECTS

ELECTIVE MODULE 9 ([5]) 6 ECTS

ELECTIVE MODULE 10 ([5]) 6 ECTS

([4]) Elective modules 6 and 7 must be chosen from among the following seven options:

ATOMIC AND MOLECULAR PHYSICS 6 ECTS

Atomic units. The hydrogen atom. Atoms with many electrons: Pauli Exclusion Principle. Hartree-Fock method. Relativistic one-electron atoms. Interaction between atoms and electromagnetic fields. Molecular structure. Molecular spectra. Atomic and molecular collisions. Computational calculation of energies and atomic wave functions. Monte Carlo simulation of radiation transport in material media.

ELECTRODYNAMICS 6 ECTS

Fundamentals on electromagnetics. Maxwell equations. Constitutive equations. Poyinting theorem. Momentum of the electromagnetic field. Electromagnetic tensor. Fields generated by an arbitrary distribution of sources. Retarded potentials. Hertzian dipole. Multipole expansion. Electromagnetic waves: propagation through dissipative media, polarization and normal incidence. Waveguides. Introduction to antenna theory. Radiation of charges in motion. Lienar-Wiechert potentials.

GENERAL RELATIVITY 6 ECTS

Covariant formulation of special relativity. Differential geometry: curvature. General relativity and Einstein equations. Physics in curved spaces. Exact solutions to the Einstein equations: black holes. Cosmological models, gravitational waves. Detection of gravitational waves.

PHYSICS OF FLUIDS 6 ECTS

Historical background. Concept of fluid as a continuum media. Fundamental equations. Constitutive equations. Application to the ideal fluid and the linear viscous fluid. Fluid statics. Ideal fluid within stationary motion: Bernoulli equation, incompressible and compressible fluids. Cavitation. Potential flow of an ideal fluid: applications. Potential flow of compressible fluids. Linear viscous flow in laminar regime. Stokes flow. Boundary layer. Non-Newtonian fluids. Instabilities. Turbulences.

PROJECTS 6 ECTS

Professional development of a physicist. Skills. Access to the working environment. Personal presentation and communication: curriculum vitae and interviews. Creation of a company: the company plan. The concept of a project. Types of projects in Physics. Project morphology. How to get projects. Project management. Presentation and communication of projects.

APPLIED OPTICS 6 ECTS

Fourier optics: historical introduction. Theory of systems limited by diffraction. Analysis of the quality of the optical systems. Optic processing techniques. Non-linear optics. Electro-optic, magneto-optic and acoustic-optic effects. Holography. Laboratory practices.

PHYLOSOPHY OF SCIENCE AND LOGIC 6 ECTS

The three levels of scientific knowledge abstraction: logic, mathematical and empirical. First order logic with identity. Theory of the definition. Origins and construction of the mathematics. Structural fundaments of empirical science: observation, measurement and experimental assessment.

([5]) Elective module 8, 9 and 10 must be chosen from among the following six options:

NANOELECTRONICS 6 ECTS

Review of quantum mechanics. The quantum particle: Fermi statistics, current, metals and insulators. Two terminal quantum dot devices. Quantum wires. Landauer theory. Field effect transistors. The electronic structure of material devices. Semiconductor memories Flash. Fundamental limits in computation. Laboratory practices.

ASTROPHYSICS 6 ECTS

Radiative transport in stellar atmospheres. Stellar structure, evolution and nucleosynthesis. Morphology and classification of galaxies. Galactic dynamics. Large-scale structure of the Universe. Cosmology: Big Bang, inflation, cosmic microwave background, anisotropy spectrum, acceleration of the Universe. Laboratory practices.

QUANTUM INFORMATION AND APPLICATIONS 6 ECTS

Classical information: Shannon, Rényi and Tsallis entropies. Quantum information: quantum bits Quantum communication. Processing of quantum information with photons. Bell inequalities. Quantum Cryptography and Teleportation. Quantum computation: logical quantum gates, quantum nets. Quantum algorithms. Trapped atoms and ions. Quantum computers.

PARTICLE AND FIELD THEORY 6 ECTS

Lorentz and Poincaré symmetries. Classical field theory. Quantization of fields. Interaction between fields. Feynman diagrams. Cross section and decay width. Quantization of the electromagnetic field. Basic processes in quantum electrodynamics. The standard model for strong and electroweak interactions. The Higgs boson. Introduction to radiative currents. Fundamentals on renormalization.

NUCLEAR STRUCTURE AND NUCLEAR REACTIONS 6 ECTS

The nuclear problem: interaction n-n and mean field theory. Independent-particle approximation (IPA). Construction of nuclear states in IPA. Qualitative and quantitative prediction of the IPA. Collective models: surface modes and density fluctuations. Theory of nuclear reactions. Electromagnetic reactions. Gamma disintegration. Weak reactions. Beta disintegration. Direct reactions: alpha disintegration. Applications of nuclear reactions. Nuclear technology. Laboratory practices.

PHYSICS OF COMPLEX SYSTEMS 6 ECTS

Complexity. Examples of complex systems. Stationary state out of equilibrium. Phase transitions Self-organization. Order parameters. Self-similarity. Chaos. Integrability and ergodicity. Liapunov coefficients.

Strange attractors. Fractal geometry and fractal dimension. Multifractality. Roughness. Solitons. Quasi-particles. Non-linear diffusion. Magnetic domains. Pattern formation. Aggregation and diffusive growth. Electrodeposition. Viscous fingers.