HELLENIC REPUBLIC

National and Kapodistrian University of Athens

EST. 1837

School of Sciences

Department of Physics

Student Guide

Academic year 2018-2019

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Presentation of the Department

Historical Note

Since the establishment of the National and Kapodistrian University of Athens in 1837, Physics has been one of the subjects taught in the School of Philosophy. The first Physics Laboratory was set up in 1890 in a separate building at 104, Solonos str. (designed by the famous German architect H. Chiller) followed by the Laboratory of Experimental Physics in 1894. A major change in the structure of the University came about 1904, when the School of Philosophy was split into two separate Schools: Philosophy and Sciences, the latter consisting of the Departments of Physics and Mathematics, and the School of Pharmacy. In 1919 the Department of Chemistry was separated from the Department of Physics. With the structural reform of 1982, the Department of Physics is now one of the Departments of the School of Sciences.

The main entrance of the building at 104, Solonos str.
(designed by the famous German architect H. Chiller)

General Description

The Department of Physics consists of five Sections where the human resources, as well as the teaching and the research activities of the Department, are allocated:

- Solid State Physics
- Nuclear and Particle Physics
- Astrophysics, Astronomy and Mechanics
- Environmental Physics and Meteorology
- Electronics, Computers, Telecommunications and Control

In the Department of Physics the following Laboratories operate:

- Laboratory of Physics "Caesar D. Alexopoulos"
- Laboratory of Computers and Informatics
- Laboratory of Mechanics and Design
- Laboratory of Solid State Physics
- Laboratory of Nuclear Physics

- Laboratory of Astronomy
- Laboratory of Astrophysics
- Gerostathopoulion University Observatory
- Laboratory of Meteorology
- Laboratory of Physical Electronics

Additionally, the following University Research Institutes are associated with the Department:

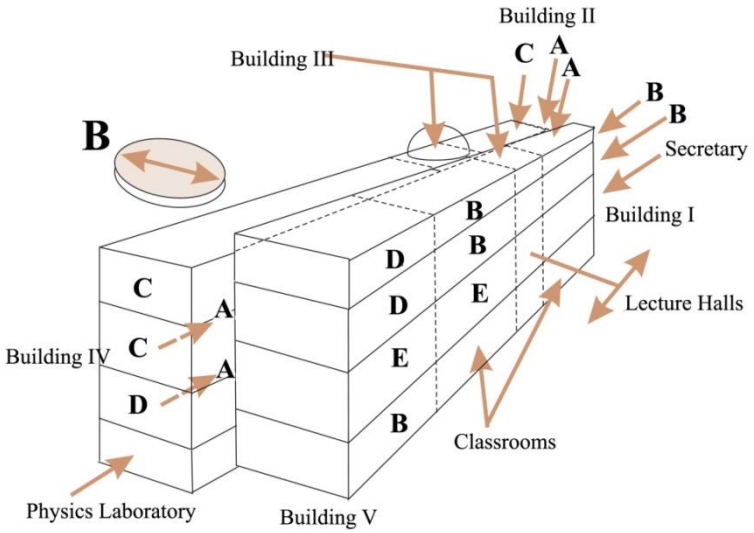
- Institute of Accelerating Systems and Applications (IASA)
- Solid Earth Physics Institute (SEPI)

The academic staff of the Department of Physics consists of 65 members: 19 Professors, 24 Associate Professors, 20 Assistant Professors, and 2 Lectures. Other staff members include: 16 members of Laboratory Teaching Staff, 1 Scientific Assistant, 7 members of Special Technical & Laboratory Staff and 13 members of Administrative Personnel.

The Department offers Undergraduate and Postgraduate studies, and awards Doctoral Degrees.

The Department of Physics is located within the School of Science complex, in a five-section building in the University Campus (Panepistimioupolis) - Ilissia.

Layout of buildings of the Department of Physics and the corresponding Sections A, B, C, D, E.



Access

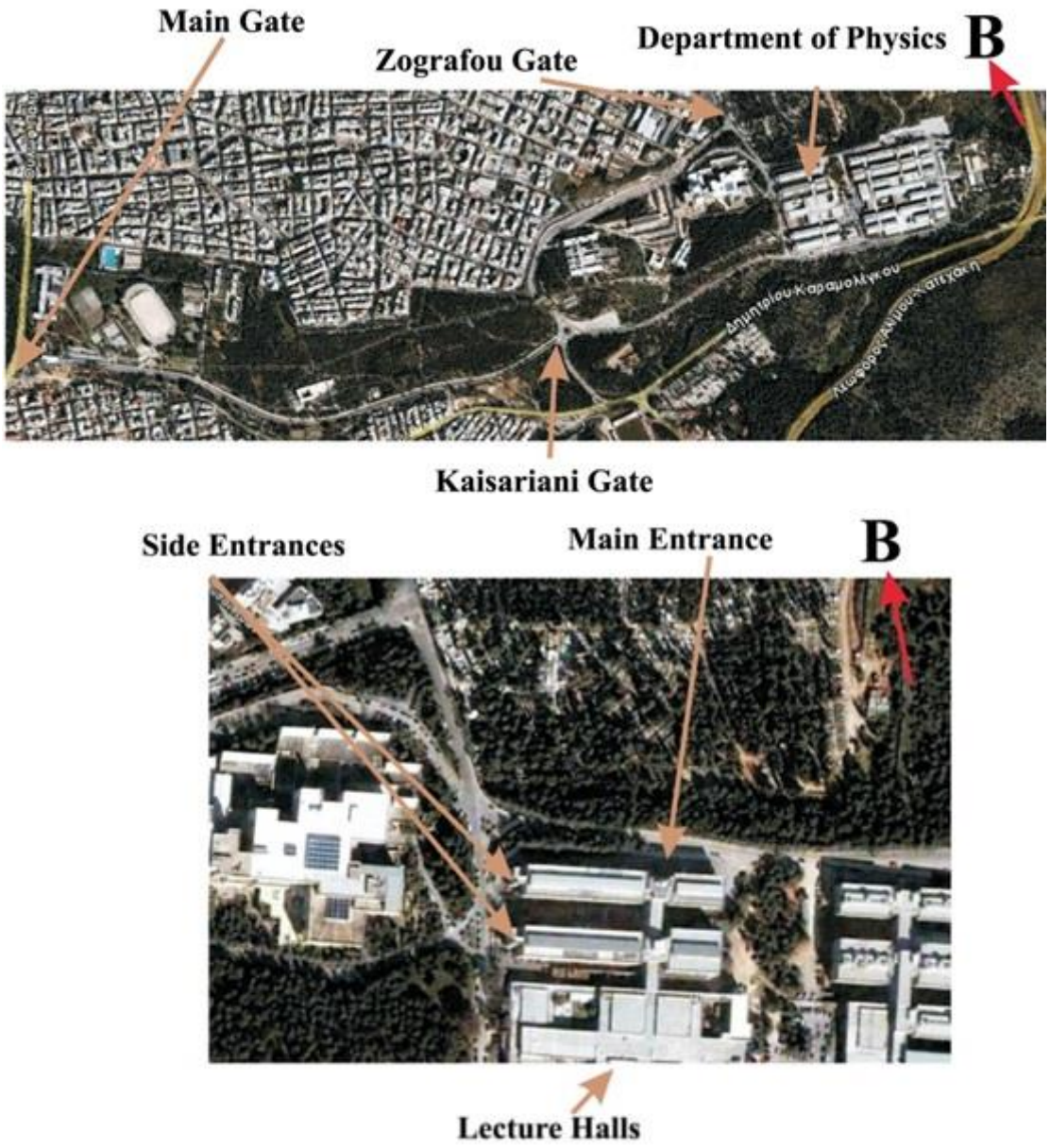
- By public transportation:

From the bus station “Evangelismos”, near the Metro station with the same name, by use of the buses 220, 221 or 235 (get off at the end of line - distance 800 m).

Alternatively by buses 250 and E90 (disembarking at the stop "Physics" - distance 100 m). Also, by buses 608 and 230 (get off at the end of line, entrance to the campus from Zografos - distance 350 m) or by bus 224 (get off at the end of line, entrance to the campus from Kaisariani - distance 1250 m).

- By car:

There is access from the three gates of the campus. The gates of Kaisariani and Zografos are open on weekdays from 7:00 to 10:00 a.m. and 2:30 p.m. to 5:00 p.m. The main gate on the Olof Palme Avenue is open every day and all hours.



The Department of Physics in the University Campus

Research

The Department of Physics exhibits a rich research activity with a great number of projects being currently developed by different research groups. Each Section of the Department focuses on subjects related to its staff members' interests, as described below.

Section of Solid State Physics

The research carried out in the Solid State Physics Section comprises a broad range of experimental and theoretical topics and activities, many of which involve collaborations with universities and research centers in Greece and abroad, in the general areas of:

Semiconducting Materials and Devices

- Infrared Spectroscopy of Point Defects
- Electrical and Optoelectronic Properties of Semiconductors
- Aging Mechanisms in Devices
- Low-dimensional Semiconductors
- Charge Transport in Amorphous Semiconductors

Strongly Correlated Materials

- Magnetism and Magnetic Materials, Spintronics
- Statistical Physics and Critical Phenomena
- Superconductivity
- Hybrid Multifunctional Materials
- Inorganic Non Metallic Materials: Synthesis, Structural Characterization, Electrical and Magnetic Properties

Nanostructured and Soft Matter

- Photonic and Phononic Nanostructures, Metamaterials
- Novel Materials of Carbon
- Dielectric Spectroscopy of Polymers and Biological Materials
- Liquid Crystals
- Electrical and Optical Properties of Low-dimensional Biological and Inorganic Structures

Physics of Complex Systems

- Physics of Solid Earth Crust
- Electromagnetic Phenomena during Breakage of Crystalline Materials
- Thermodynamics of Systems far from Equilibrium
- Propagation of Electromagnetic Signals in Heterogeneous Media
- Extreme Phenomena by terms of Complexity

Section of Nuclear and Particle Physics

The research activities of the Section of Nuclear and Particle Physics focus on studying the fundamental properties of nuclei and subatomic particles, as well as their applications. The academic staff of the Section comprises both experimentalists and theorists, who are active in a broad range of subjects in collaboration with universities and research centers in Greece and abroad.

Theoretical Research

Nuclear Physics

- Theoretical Nuclear Physics

Particle Physics

- Open Quantum Systems and Quantum Information Group
- Particle Physics, Field Theory and Cosmology Group
- Quantum and Classical Gravity Group
- Strings, Fields and Mathematical Physics Group
- Theoretical Particle Physics beyond the Standard Model Group

Experimental Research

Nuclear Physics

- NuSTRAP Group (Nuclear Structure, Reactions & Applications)

Particle Physics

- ALICE Group
- ATLAS muon / GlueX Group
- UoA_CMS Group

Cosmic Rays

- Cosmic Ray Group

Ion-beam and Radiation Applications

- Medical Physics

Section of Astrophysics, Astronomy and Mechanics

The faculty members of the Section are conducting research in various areas of Astrophysics, Astronomy and Theoretical Mechanics, as well as in topics pertaining to the History and Philosophy of Physics and Astronomy. In the frame of this research, collaborations with well-known research centers, astronomical institutes and universities in Greece and abroad have been established, in both theoretical and observational projects.

Main Areas of Research

- Astronomy and Astrophysics
- Observational Astronomy and Astrophysics
- Theoretical Astronomy and Astrophysics
- High Energy Astrophysics
- Plasma Astrophysics

- Cosmology - Relativity
- Dynamical Astronomy
- Space Physics
- Theoretical Mechanics
- Applied Optics
- History and Philosophy of Sciences

Specific Fields of Research

- Plasma Astrophysics
- Interacting Binary Stars
- Astronomical Photometry and Spectroscopy
- Image Processing
- High Energy Astrophysics
- Structure and Evolution of Stars – Stellar Atmospheres
- Accretion Disks in Astrophysical Environments
- Dynamics of Celestial Bodies - Hydrodynamics
- Dynamical Astronomy
- Extragalactic Astronomy
- Data Reduction from Earth-based and Space Observatories
- Applied Optics
- Solar Physics
- Classical and Relativistic Mechanics
- Cosmology and Relativity
- Cosmic Radiation – Stellar Winds
- Variable Stars
- Non-Linear Dynamics
- Relativistic Astrophysics – Gravitational Waves
- Space Physics
- History and Philosophy of Astronomy and Applied Sciences

Section of Environmental Physics and Meteorology

The research carried out in the Environmental Physics – Meteorology Section includes a wide range of experimental and theoretical topics and activities, in such thematic fields as:

- Atmospheric Physics
- Meteorology and Climatology
- Atmospheric Dynamics
- Climate and Climate Change
- Numerical Modelling for Atmospheric Applications
- Atmospheric models and weather prediction
- Air quality (including indoor air quality)
- Boundary Layer Physics
- Remote Sensing and Image Processing
- Building Physics
- Renewable Energy Sources
- Physical Oceanography

All thematic fields above are supported by respective research units and state-of-the-art research instrumentation (including tailor-made software for atmospheric and other environmental applications).

Section of Electronics, Computers, Telecommunications and Control

The Section carries out research in areas such as Physics of Electronics and Applications, Theory and Applications of Telecommunications, Physics of Information, Computers, as well as Systems of Automatic Control. All these areas are of high interest worldwide and lead the modern technological advances. In particular, research interests of the Section include the following:

Electronic Circuits
- Analysis / Synthesis of Analog and Digital Circuits
- RF Applications / Electroacoustics

Physics of Semiconductors - Microelectronics
- Processes / Design
- Structures / Nanostructures

Electromagnetism
- Antennas / Propagation
- Theory and Applications of Microwaves

Optics
- Optoelectronics / Photonics
- Optical Communications

Telecommunications
- Physical layer - Systems
- Protocols

Signals - Multimedia
- Signal Processing
- System Recognition

Automatic Control
- Classical and Multivariable Control
- Complex Automatic Control Systems and Graphs

Computers
- Algorithms / Software
- Parallel Systems / Real-time Systems
- Physics of Information

Nonlinear Waves and Solitons with applications
- Bose-Einstein condensation, nonlinear optics, metamaterials
- water waves, acoustics

Undergraduate Studies

Introduction

The current program of undergraduate studies in the Department of Physics (implemented in the academic year 2011-12), has been the result of considerable reform and modernization, bringing it fully in line with contemporary major trends in both teaching and research.

Physics has always been considered the cornerstone of scientific development. Nowadays, it underpins a breadth of disparate scientific disciplines, while it continues to be indispensable in helping us understand the world around us. It challenges our imagination and develops our deepest thinking with profound concepts, such as quantum mechanics, relativity and string theory. It also leads to technologies essential for our lives, such as machines, computers, lasers and sustainable energy products.

Our undergraduate program has been set up with a dual aim: On one hand, to expose our students to the in-depth study of the world, from galaxies to subatomic particles, providing them with versatile analytical and problem-solving skills. On the other hand, to help them develop a broader perspective to problems, not necessarily bound by context, so that they can be valuable in any scientific field. Indeed, following the completion of their studies in physics, many of our students have thrived in engineering, computer science, medicine, biology, management, finance, law, etc.

Our Department assigns Advisors to the students, with the benefit of their professional guidance throughout their undergraduate studies.

Outline of the Program of Studies (Curriculum)

The studies in the Department of Physics of the National and Kapodistrian University of Athens are demanding, but also fully modernized and competitive internationally. According to international rankings, the Department is one of the strongest in the University, having recently been ranked among the **top 75-100** Physics Departments in the world (Academic Ranking of World Universities, 2017).

The main undergraduate cycle of studies (curriculum) lasts for four (4) years and leads to a BSc in Physics with a total number of ECTS credits of 240. The four years of study are divided into eight (8) semesters, each of which lasts 13 weeks. The average daily attendance by students ranges between 4 and 5 hours, thereby corresponding to an average of 22 hours per week. The program requires a choice of a ***specialization*** in the middle of the 3rd year, so that during the 4th and final year a student may choose a specific set of physics courses according to his/her preferences and special interests.

These general specializations are: i) **Solid State Physics**; ii) **Nuclear & Elementary Particle Physics**; iii) **Astrophysics**, **Astronomy** and **Mechanics**; iv) **Environmental Physics** and **Meteorology**; v) **Electronics**, **Computers**, **Telecommunications** and **Control.** They correspond to the five (5) Sections comprising the Department of Physics.

The choice of specialization is possible after the student has been successfully tested in at least 15 courses and the corresponding laboratories of the first 5 semesters.

Structure and Philosophy of the Curriculum

The Curriculum, which has been in place since the academic year 2011-12, includes:

- 35 theory courses
- 7 laboratories, i.e. courses of laboratory exercises,
- 1 diploma thesis,

with the courses being characterized as **Core** or **Specialization** courses, and **Compulsory** or **Elective** courses.

The **35 theory courses** are divided into:

- 25 Compulsory Core courses
- 1 Elective Core course (selected from 3 Elective Core courses)
- 6 Specialization courses (3 of which are Compulsory Specialization courses, while the remaining 3 are Elective Specialization courses from the Specialization that has been selected by the student)
- 3 additional Free Elective courses (from any Specialization, or Elective courses from other Departments of the University),

while the **7 laboratories** include:

- 4 Basic Physics laboratories (associated to Physics I, II, III and IV courses)
- 2 Core laboratories (Core laboratories I and II)
- 1 Specialization laboratory.

The **Diploma Thesis** usually has a subject in an area of the Specialization that has been selected by the student. It is carried out during the last (4^{th}) year of study, always in consultation and under the supervision of an advising professor (not necessarily the same as the student's Advisor). It has a specific weight, corresponding to 15 ECTS credits, i.e., roughly more than that of two courses.

The **completion of the undergraduate studies** is certified by the Secretariat of the Department with the assignment of **44** eligible grades, i.e., those for 35 courses, 7 laboratories, and a two-course grade for the diploma thesis. The average of these 44 grades is the **grade of the BSc Degree**.

The outline of the curriculum intends to underline the importance for the student to follow the chronological order of the courses per semester and year. The 1^{st}-year courses and, even more so, those of the first semester highlight the inherently different educational approach of the university as compared to that of the high school. The attendance of all courses by the students on a weekly basis is necessary for a smooth adaptation to the requirements of a university degree and the avoidance of gaps in knowledge that might make it challenging to follow more advanced courses.

The 1st- and 2d-year courses, i.e., those of the first four semesters, provide the necessary background and skills to follow the courses of the upcoming semesters, as they focus on general physics and mathematics. In particular, these courses cover basic concepts in physics and employ mathematical methods to arrive at both qualitative and quantitative conclusions, and thus establish fundamental laws of physics. More specifically, these four semesters include:

- **Courses of general-physics content**. This set consists of four (4) courses offered sequentially, one per semester: Physics I (winter semester) and Physics II (spring semester) in the 1st year, Physics III (winter semester) and Physics IV (spring semester), in the 2d year. These courses constitute the basis for understanding fundamental concepts in Physics and should be followed according to the sequence set up in the curriculum.

- **General-physics laboratories (laboratory exercises).** The aim of these Laboratories is to complement the theoretical knowledge of the general physics courses. There exist four (4) such laboratories -one per semester- which are mandatory. The scope of the 1st semester laboratory is to introduce the scientific methodology for obtaining and processing experimental data. The laboratory exercises of the next three semesters correspond to the theoretical subjects of the general physics courses.

- **Courses of mathematical and general content**. There are seven (7) such courses, which also include Computational Physics, Computers-I and Probability-Statistics, which are indispensable in almost all contemporary scientific specializations.

- The courses **Mechanics I**, **Mechanics II**, and **Special Theory of Relativity** complete the basic core courses of the first two years.

- **Two rounds of seminar courses** during the 1st year (one round in each of the 1st and the 2nd semesters), which are mandatory, but without examination requirements. Their scope is to provide the first-year students with a broad picture of various areas of physics, as well as current developments.

The curriculum's "core" of the first two years is completed by the courses and advanced laboratories of the 3d year, which include the Core Laboratories I (5th semester) and II (6th semester). At the beginning of the 6th semester, the students have obtained a broad picture of the existing areas of physics and, hence, can follow one of the five (5) Specializations offered, according to their interests. Courses of the 6th semester include:

• Three (3) final **Compulsory Core courses** and the **Core Laboratory II**
• One, out of the three, **Compulsory Specialization courses**
• One **Elective Core course,** out of the three (3) offered.

Finally, in the 4th year of study, i.e. in the 7th and 8th semesters, the students should attend **Specialization courses,** i.e., the remaining 2 **Compulsory** and the 3 **Elective Specialization courses**, the **Specialization laboratory**, the 3 **additional Free Elective courses**, as well as the **diploma thesis.**

Students' Advisors

Each year, shortly after the enrolment process, each faculty member is appointed as Advisor (mentor) to a number of students in order to monitor them during their studies. The students are invited to contact and get acquainted with their respective Advisor. They are encouraged to consult him/her on any issue related to their studies. Based on the current number of faculty members and the number of first-year students, each faculty member currently mentors 3 to 4 students.

The Curriculum per Year of Studies

In the following, the curriculum is presented per semester. The presentation is in the form of a table, showing the courses, the corresponding ECTS credits and the weekly hours for Theory-Exercises (Tutorial)-Laboratories (Lab). A course syllabus is provided following each table.

Abbreviations on the type of courses:

COMCOR = compulsory core course
ELECOR = elective core course
COMSPE = compulsory specialization course
ELESPE = elective specialization course
FREELE = free elective course

1st Semester						
CODE	**COURSE TITLE**	**TYPE**	**TEACHING HOURS**			**ECTS**
			Theory	**Exercises**	**Lab**	
Y0312	Analysis I and Applications	COMCOR	4	2		6
Y013	Physics I (Mechanics)	COMCOR	4	2		6
Y0314	Physics I Basic Laboratory	COMCOR			2,5	3
Y015	Computers I	COMCOR	2		2	6
Y0317	Probabilities, Statistics and Applications of Numerical Analysis	COMCOR	2	2		6

Y0312. Analysis I and Applications

- Numbers (natural, integers, rational, irrational, real).
- Bounded and unbounded sets, upper and lower bounds (supremum, infimum).
- Sequences, series and power series (radius of convergence).
- Continuous functions.
- Differentiation, mean value theorem, extrema of functions, Taylor's theorem, fundamental functions.
- Integrals (definite and indefinite), exact and approximate methods, applications in physics.

Y013. Physics I (Mechanics)

- Linear motion, curvilinear motion, relative motion, introduction to the special theory of relativity.
- One-body dynamics.
- Work, energy, many-body dynamics.
- Rigid body rotation around a fixed axis.
- Rolling, angular momentum and torque, oscillations.
- The universal gravitation law, fluid mechanics.

Y0314. Physics I Basic Laboratory

Introductory Laboratory: The experimental methodology, measurement, experimental uncertainty, instrumentation, accuracy, results, graphical representations. Preparation and design of experiments, error propagation. Introduction to new technologies, interface, sensors PC, S / W (Logger Pro), least squares method, errors.

- Applications of error theory, calculations.
- Experimental procedures.
- Familiarization with the laboratory software.
- New technologies in measurements.
- Electrical circuits.
- Dimensional calculations using vernier, calculation of composite relative errors. Experimental study of buoyancy.

Y015. Computers I

- Computer structure and operation, operating systems.
- Algorithms, program structure.
- Programming in C language.

- Controlling program flow, conditions, loops.
- Arrays, file processing, pointers, functions.
- Global and local variables.
- Examples, applications in physics.

Y0317. Probabilities, Statistics and Applications of Numerical Analysis

- Basic probability definitions, combinatorics for probability selection with and without replacement.
- Random variables and distributions, discrete and continuous distributions, asymptotic results, central limit theory.
- Descriptive statistics, data grouping, measures of central tendency and variance.
- Hypothesis tests, significance tests for the mean value and variance of normal populations, significance test of the correlation coefficient, goodness of fit tests.
- Computational applications: Introduction to Monte Carlo methods and computational applications in estimating probabilities.
- Introduction to parameter estimation methods, computational implementation and applications of the method of moments, mean value, variance, higher moments, computational implementation and applications of the least square method.

2nd Semester

CODE	COURSE TITLE	TYPE	TEACHING HOURS			ECTS
			Theory	Exercises	Lab	
Y0321	Ordinary Differential Equations and Linear Algebra	COMCOR	4	2		6
Y0322	Analysis II and Applications	COMCOR	2	3		6
Y0323	Physics II (Heat and Waves)	COMCOR	4	2		6
Y0324	Physics II Basic Laboratory	COMCOR			2,5	3
Y025	Introduction to Astrophysics	COMCOR	4	1		6

Y0321. Ordinary Differential Equations and Linear Algebra

- Linear spaces, linear transformations.
- Determinants, eigenvectors and eigenvalues.
- Ordinary differential equations.
- Linear differential equations.
- Systems of differential equations.

Y0322. Analysis II and Applications

- Vectors, vector functions, inner and outer product, lines, planes, surfaces, arc length, unit tangent vector, TNB frame, multivariable functions, derivatives, limit, continuity.
- Partial derivatives, chain differentiation, directional derivative, tangent planes, linearization, differentials, extrema and saddle points.
- Lagrange multipliers, partial derivatives of functions under constraints, Taylor's theorem for multivariable functions.
- Curvilinear coordinate systems, norm, gradient, divergence and curl.

- Double and triple integrals in Cartesian and other coordinates, applications to the evaluation of areas, moments of inertia and centers of mass, change of variables (Jacobian determinants).
- Integration of vector fields, line and surface integrals, path independence, potential functions and conservative fields, Green, Gauss and Stokes theorems and applications.

Y0323. Physics II (Heat and Waves)

- Ideal gas, kinetic theory of gases, Maxwell distribution, temperature, internal energy, heat capacity.
- Work, heat, first and second law of thermodynamics, reversible processes, entropy, thermal engines.
- Oscillations and waves, wave equation, plane and spherical waves.
- Superposition, interference, diffraction, polarization, sound waves, Doppler effect.
- Geometrical optics (reflection, refraction), mirrors, lenses, prisms.

Y0324. Physics II Basic Laboratory

- Harmonic oscillator.
- Atwood engine (using photogates).
- 2^{nd} and 3^{rd} Newton's laws of motion, impulse and collisions.
- The Cavendish experiment.
- Rigid body rotation, moments of inertia, static and kinetic friction.
- Natural and rotational pendulum.
- Non-ideal gas processes using sensors and computers.

Y025. Introduction to Astrophysics

- Basic concepts, radiation field, transfer equation, stellar luminosity, stellar brightness, stellar magnitudes and distances, coordinate systems.
- Spectral classification of stars, Hertzsprung-Russel diagram, stellar structure.
- Formation of proto-stars, formation of stars, stellar evolution, the last stages of a star’s life, novae and supernovae, neutron stars, black holes.
- The sun, quiet and active sun.
- The solar system: Kepler laws, the law of Titius-Bode, inner planets, outer planets, dwarf planets, satellite planets, small bodies (asteroids, comets, TNT objects, meteorites etc.).
- Galaxies: Basic concepts, definition of a galaxy, morphological classification, elliptical galaxies, spiral galaxies, irregular galaxies, dwarf galaxies, dark matter, rotation curves of spiral galaxies, density profiles of dark matter halos, decomposition of rotation curves.
- Our galaxy: anatomy of the galaxy, stellar populations, rotation curve of the galaxy.
- Local group of galaxies.
- Cosmology.

3nd Semester						
CODE	**COURSE TITLE**	**TYPE**	**TEACHING HOURS**			**ECTS**
			Theory	**Exercises**	**Lab**	
Y031	Theoretical Mechanics I	COMCOR	2	2		6
Y032	Physics III (Electromagnetism)	COMCOR	4	2		6
Y0333	Physics III Basic Laboratory	COMCOR			2,5	3
Y034	Mathematical Methods for Physics I	COMCOR	3	2		6
Y035	Introduction to Atmospheric Physics	COMCOR	3	2		6
Y0338	Computational Physics	COMCOR	2	2		6

Y031. Theoretical Mechanics I

- Kinematics of a point object.
- Inertial systems, Newton's laws, conservation laws, conservative forces, integrals of motion.
- Impulsive forces, collisions, moving coordinate systems (motion in a non-inertial system and applications).
- Systems with one degree of freedom (motion boundaries, study of equilibrium points with perturbation methods and phase diagrams, harmonic oscillator).
- Central forces (integrals of motion, circular orbits and their stability, inverse square forces, Kepler's laws).
- Scattering, many-body systems and their motion, the two-body problem, variable-mass systems.
- The gravitational field, gravitation from extended bodies, tidal forces.

Y032. Physics III (Electromagnetism)

- Electric charge, Coulomb's law, electric field, field lines, electric potential, potential difference, conductors, Gauss' law, examples.
- Electric field of a spherical shell, capacitance, capacitors, dielectrics, electric current, resistance, Ohm's law, magnetic field, Laplace's force, force on a conductor, applications.
- The electric current as a source of magnetic field, Biot-Savart law, Ampere's law, applications.
- Induction, Faraday's law, coefficient of self-induction, RL and RLC circuits and mechanical analogues.
- Maxwell's equations in integral and differential form, energy of electromagnetic field, Poynting vector.
- Qualitative explanation of the propagation of an electromagnetic field perturbation, electromagnetic waves.

Y0333. Physics III Basic Laboratory

- Adiabatic processes, evaluation of the γ coefficient, Otto cycle.
- Geometrical optics, lenses, dispersion, prisms.

- Measurement of the propagation velocity of elastic waves in solids, normal modes, eigenfrequencies (Fourier analysis).
- Phenomena of interference and diffraction of light (Young), polarized light.
- Wave phenomena with microwaves (reflection, refraction, standing waves, polarization).
- Doppler effect (of sound).

Y034. Mathematical Methods for Physics I

- Complex numbers, elementary functions of a complex variable, multivalued functions, branches.
- Continuity, derivative of a complex function, Cauchy-Riemann equations, harmonic functions, fundamental analytical functions.
- Complex power series, Taylor and Laurent series, classification of singularities, contour integral, Cauchy theorem, residue theorem, principal value, evaluation of series and integrals.
- Conformal mapping, applications in physics.
- Fourier and Laplace transforms, applications to differential equations, asymptotic methods, stationary phase and steepest descent methods.

Y035. Introduction to Atmospheric Physics

- Composition and structure of the atmosphere, planetary atmospheres.
- Solar and terrestrial radiation.
- Photochemical processes in the atmosphere.
- Atmosphere and the climatic system.
- Thermodynamics and statics of the atmosphere.
- Atmospheric motions.

Y0338. Computational Physics

- Numerical calculations and uncertainties, numerical solution of algebraic equations of one variable.
- Numerical solution of systems of algebraic equations, polynomial interpolation, numerical differentiation.
- Numerical integration.
- Numerical solution of ordinary differential equations.
- Numerical solution of partial differential equations.
- Introduction to Monte Carlo methods.

4th Semester						
CODE	**COURSE TITLE**	**TYPE**	**TEACHING HOURS**			**ECTS**
			Theory	**Exercises**	**Lab**	
Y041	Theoretical Mechanics II	COMCOR	2	2		6
Y0343	Physics IV Basic Laboratory	COMCOR			2,5	3
Y044	Mathematical Methods for Physics II	COMCOR	3	2		6
Y0345	Physics IV (Modern Physics)	COMCOR	4	2		6
Y046	Special Theory of Relativity	COMCOR	2	2		6
Y0347	States and Properties of Matter	COMCOR	2	2		6

Y041. Theoretical Mechanics II

- The principle of least action.
- Calculus of variations, Euler-Lagrange equations, Lagrangian of a charged particle in an electromagnetic field.
- Symmetries and Noether theorem, Lagrange multipliers and constraints.
- Normal modes of an oscillating system.
- Legendre transformation, Hamilton's equations, phase space flow, Poisson brackets.
- Symmetries and conserved quantities in Hamiltonian mechanics, canonical transformations.

Y0343. Physics IV Basic Laboratory

- Magnetic field of circular conductors and coils, Biot-Savart law.
- Study of RLC resonance circuit – use of oscilloscope.
- Power generation, Lenz's law (motor, generator, stroboscope).
- Motion of electrons in a homogenous magnetic field, measurement of charge-to-mass ratio.
- Hall effect, conductors, carriers calculation.
- Spectroscopy, spectral lines and Bohr's theory.
- Photoelectric effect.
- Transformers: operation and current-voltage characteristics.

Y044. Mathematical Methods for Physics II

- Inner product spaces (Cauchy-Schwarz inequality, Gram-Schmidt orthonormalization).
- Complete infinite-dimensional functional spaces (Bessel inequality, Parseval equality, basis of an infinite-dimensional space).
- Fourier series (Weierstrass theorem), linear operators in complete spaces (self-adjoint operators eigenvalue problems, spectral theorem of self-adjoint operators), Sturm - Liouville systems.
- Introduction to partial differential equations of mathematical physics (wave, diffusion, and Laplace equations), classification of partial differential equations, characteristic surfaces, boundary conditions, methods of solution.

- The homogeneous and inhomogeneous wave equation, solution in Cartesian, cylindrical and spherical coordinates.
- The diffusion equation subject to homogeneous and inhomogeneous boundary conditions in Cartesian, cylindrical and spherical coordinates, Green's functions.

Y0345. Physics IV (Modern Physics)

- Relativistic energy and momentum of particles, four-vector momentum-energy, invariant mass, black body radiation, photoelectric effect, Compton effect, braking radiation, creation and annihilation of particle-antiparticle pairs.
- de Broglie waves, Heisenberg's uncertainty principle, two-slits experiments, probability amplitude, wave function, Schrödinger's equation, one-dimensional potential well problems.
- Bohr's atomic model, the quantum mechanical model of the atom, the hydrogen atom.
- Angular momentum and spin, magnetic moments, fine structure.
- The exclusion principle, atomic spectra, lasers and applications.
- Molecular binding, metals and semiconductors, superconductivity, nuclear structure and properties, nuclear reactions.
- Nuclear fission and fusion, elementary particles and their interactions, accelerators and detectors. Interaction of particles with matter.

Y046. Special Theory of Relativity

- Tensors (covariant and contravariant four-vectors, metric).
- Spacetime (space-like, time-like, light-like four-vectors).
- Relativistic Kinematics and dynamics (Lorentz transformations, invariant quantities, four-velocity, four-acceleration, four-momentum).
- Paradoxes in special relativity and their analysis.
- Relativistic particle reactions (conservation of four-momentum).
- Special relativity and electrodynamics (covariant formulation of Maxwell equations, electric and magnetic field transformations).

Y0347. States and Properties of Matter

- Solids (periodic and quasi-periodic crystals, amorphous and fractal solids), self-similarity, Bose-Einstein condensates, real gases and liquids, mesophases.
- Symmetry group operations, crystal lattices in 1, 2 and 3 dimensions.
- Atomic bonding, hybridization.
- Linear elasticity, viscoelasticity, elastic waves.
- Surface tension and wetting.
- Transport phenomena, state/phase transitions, thermodynamic potentials.

5th Semester						
CODE	**COURSE TITLE**	**TYPE**	**TEACHING HOURS**			**ECTS**
			Theory	**Exercises**	**Lab**	
Y051	Electronics I	COMCOR	3	2		6
Y053	Quantum Mechanics I	COMCOR	3	2		6
Y054	Electromagnetism I	COMCOR	3	2		6
Y0355	Statistical Physics I	COMCOR	2	2		6
Y0356	Core Laboratory I	COMCOR			3	3

Y051. Electronics I

- Introductory concepts, signals and systems.
- Elements of circuit analysis and quadrupole theory, time and frequency domain analysis of circuits.
- Introduction to operational amplifiers, circuits and applications.
- Elements of semiconductor physics, diodes and applications.
- The bipolar junction transistors, operation and applications.
- The field effect transistor, operation and applications.

Y053. Quantum Mechanics I

- Introduction to quantum mechanics, the Schrödinger's equation.
- Principles of quantum mechanics, observables, mean values, uncertainty.
- Time evolution of systems and observables.
- The uncertainty principle, energy-time uncertainty.
- Particles in one-dimensional potentials, the one-dimensional harmonic oscillator.
- One-dimensional scattering problems.

Y054. Electromagnetism I

- Mathematical background (delta function, Helmholtz theorem), conductors and capacitors, general properties of the solutions of Laplace's equation, uniqueness theorems.
- Solution methods (method of images, inversion method), boundary-value problems in Cartesian, spherical and cylindrical coordinates.
- Multipole expansion, dielectrics, polarization, bound charges.
- Electric displacement, linear dielectrics, dielectrics and capacitors, solution of Laplace's equation in dielectrics, energy and forces in linear dielectrics.
- Magnetostatics, Ampere's law, vector potential, techniques for determining the vector potential, magnetostatic fields in matter.
- Paramagnetic and diamagnetic materials, magnetization, bound currents, magnetic field, linear magnetic media, magnetic scalar potential, ferromagnetism.
- Induction law, Maxwell's equations.

Y0355. Statistical Physics I

- Introduction.
- Isolated system, microcanonical ensemble.
- System in a thermal bath, canonical ensemble.
- Classical statistical physics.

- The grand canonical ensemble.
- The quantum ideal gas.

Y0356. Core Laboratory I

- Introduction to basic concepts and instrumentation in electronics, electrical and electronic circuits.
- Signals and systems, introduction to operational amplifiers and applications.
- Radiation of stars (sun), measurement of star properties.
- Evolution of stars, star clusters, age and distance measurement, the expansion of the universe and the Hubble's constant.
- Measurements and study of basic atmospheric parameters: short and long wave solar and earth radiation. Temperature and humidity.
- Wind: Basic concepts, measurements, data analysis and presentation. Thermodynamic changes in vertically moving air mass, tephigram, vertical stability.

6th Semester

CODE	COURSE TITLE	TYPE	TEACHING HOURS			ECTS
			Theory	Exercises	Lab	
Y061	Introduction to Nuclear Physics and Elementary Particles	COMCOR	2	2		6
Y062	Introduction to Solid State Physics	COMCOR	3	2		6
Y065	Quantum Mechanics II	COMCOR	3	2		6
Y0367	Core Laboratory II	COMCOR			3	3

Y061. Introduction to Nuclear Physics and Elementary Particles

- Characteristic scales and units, the standard model, quarks & leptons, conservation principles, relativistic kinematics.
- The field concept, interactions via boson exchange, Yukawa theory, Feynman diagrams, virtual particles, antiparticles, electromagnetic and weak interactions and their unification.
- Chromodynamics, strong interactions, symmetries (parity, charge conjugation, time reversal), static quark model, hadron classification.
- Properties of nuclei, valley of β-stability, semi-empirical formula, mirror nuclei.
- Charge distribution, scattering of electrons from nuclei, radioactivity, α-decay, tunneling effect.
- Nuclear potentials, deuterium, mean field theory, independent particle model, L-S coupling, nuclear shell model.

Y062. Introduction to Solid State Physics

- The structure of solid matter, Bravais lattices, unit cell.
- Reciprocal lattice, diffraction from periodic structures, Bragg's law.
- Attractive and repulsive interactions in solids-cohesion (inert-gas and ionic crystals, metals).

- Lattice vibrations, exact solution of the monoatomic and diatomic linear chain, phonons.
- Electron states in a periodic potential, the Kronig - Penney model, metals, semiconductors and insulators.

Y065. Quantum Mechanics II

- Many-body Schrödinger's equation, quantum mechanics in three dimensions.
- Orbital angular momentum, central potentials and the hydrogen atom.
- Dirac's notation, harmonic oscillator (creation and annihilation operators), Schrodinger's and Heisenberg's picture.
- Angular momentum and spin, addition of angular momenta, identical particles and Pauli's exclusion principle.
- Interaction of charged particles with electromagnetic fields, Zeeman effect, time-independent perturbation theory.
- The real hydrogen atom.

Y0367. Core Laboratory II

- Basic concepts of semiconductors and semiconductor devices, p-n junction and applications.
- Bipolar-junction and field-effect transistors in linear and nonlinear operation mode, applications.
- The energy gap of germanium.
- Electron diffraction from polycrystalline graphite.
- Geiger-Muller detectors, detection and absorption of β and γ radiation
- Scintillator detectors, interaction of γ radiation with matter, dosimetry.

7th Semester

CODE	COURSE TITLE	TYPE	TEACHING HOURS			ECTS
			Theory	Exercises	Lab	
Y071	Diploma Thesis I	COMCOR				7.5

8th Semester

CODE	COURSE TITLE	TYPE	TEACHING HOURS			ECTS
			Theory	Exercises	Lab	
Y081	Diploma Thesis II	COMCOR				7.5

Elective Core Courses						
CODE	**COURSE TITLE**	**TYPE**	**TEACHING HOURS**			**ECTS**
			Theory	**Exercises**	**Lab**	
Y3404	Electromagnetism II	ELECOR	2	2		6
E0391	Statistical Physics II	ELECOR	2	2		6
E0392	Fluid Dynamics	ELECOR	2	2		6

Y3404. Electromagnetism II

- Applications of Maxwell's equations, electromagnetic potentials and Coulomb and Lorenz gauges.
- Maxwell's stress tensor, momentum conservation.
- Electromagnetic waves in dielectrics and conductors, dispersion.
- Waveguides, resonant cavities and optical fibers.
- Electromagnetic radiation, electric and magnetic dipole radiation (Lienard-Wiechert potentials, fields from moving charges).
- Radiation reaction.

E0392. Statistical Physics II

- Phase equilibrium.
- First- and second-order phase transitions, stability and fluctuations.
- Weiss and van der Waals theories (critical temperature, critical exponents, mean field).
- Statistical physics of liquids.
- Nucleation, spinoidal decomposition.
- Landau theory, order parameter, Landau-Ginzburg criterion, critical phenomena.
- Inhomogeneous systems.
- Statistical mechanics of polymers, Flory theory, exclusion volume, glass transition.
- Statistical mechanics of protein folding.
- Interfaces, wetting, transitions.

E0392. Fluid Dynamics

- Introduction, kinematics and conservation laws, Euler and Navier-Stokes equations.
- Bernoulli equation, hydrostatics, gravity waves.
- Instability: General theory, Rayleigh-Taylor and Kelvin-Helmholtz instabilities.
- Introduction to turbulence, turbulent flows and the turbulent kinetic energy.
- Geophysical fluid dynamics: Coordinate systems and the effect of the Earth's rotation, scaling, vorticity conservation.
- Rotation effects in geophysical flows: Geostrophic balance, Ekman dynamics, barotropic waves in the presence of rotation, stratification effects in geophysical flows: Stratified geostrophic dynamics, internal waves
- Supersonic flow and shock waves, computational fluid dynamics.

Free Elective Courses						
CODE	**COURSE TITLE**	**TYPE**	**TEACHING HOURS**			**ECTS**
			Theory	**Exercises**	**Lab**	
E3910	Applied Optics	FREELE	2	2		5
E3911	Stochastic Processes in Physics	FREELE	2	2		5
Y3406	Atomic and Molecular Physics	FREELE	2	2		6
E3991	Current issues on Cell Biology	FREELE	2	2		5
E3996	Differential Geometry and Applications	FREELE	2	2		5
E3997	Chemistry	FREELE	2	2		5
E3998	Chemistry Laboratory	FREELE			4	5

E3910. Applied Optics

- Optical imaging theory (first and third order), ray tracing, optical aberrations (lens and mirrors), optical aberration correction.
- Optical systems, image quality criteria.
- Interference, interferometry, diffraction (near and far field), spectrographs.
- Holography, optical guidance systems, optical materials, optics of solids.
- Polarization, polarimetry, Fourier optics.
- Laboratory exercises.

E3911. Stochastic Processes in Physics

- Introduction to probability theory – random variables and their distributions, Bayes theorem, hypothesis testing, statistical inference, random processes (stationarity and independence), correlation functions.
- Spectral properties – power spectrum and autocorrelation, linear filters.
- Random walks: Wiener processes and Brownian motion.
- Diffusion: Diffusion equation, Fokker-Planck equation.
- Noise: Thermal noise, shot noise.
- Entropy, maximum entropy distributions, complexity.
- Markov chains: Transition matrices and ergodicity.

Y3406. Atomic and Molecular Physics

- The hydrogen atom, the spin of electron and the interaction with an external magnetic field, coupling with orbital angular momentum, spectra, fine structure.
- Multi-electron atom, helium spectrum, Pauli's principle, Hartree theory, L-S coupling and J-J coupling, magnetic moments.
- Spectra of multi-electron atoms, interaction with an external field, multiple excitations, hyperfine structure, laser.
- Fundamental principles of molecular physics, Born-Oppenheimer approximation and two-atom molecules.
- The linear combination of atomic orbitals (LCAO), energy level diagram and molecular spectra, symmetries in molecules.
- Experimental methods in molecular spectroscopy.

E3991. Current issues on Cell Biology

- Structural elements, cellular organization.
- Organization and function of a model cellular system.
- Biological membranes, separative functional double layers.
- First step of genetic information flow: Levels of DNA organization.
- Second step of genetic information flow: Protein synthesis.
- Post-translational modification, endoplasmic reticulum, Golgi apparatus.
- Cellular organelles producing and converting energy: Mitochondria and chloroplasts.
- Organelles processing and degrading biomolecules: Peroxisomes and lysosomes.
- Cellular fibrils, cytoskeleton.
- Cellular communication and conjunction.
- Extracellular matrix.
- Cell cycle, reproduction.
- Principles of signal transduction.

E3996. Differential Geometry and Applications

- The concept of a curve, arc length of a curve, tangent, osculation plane and normal plane, curvature, moving trihedron of a curve, torsion, Frenet types, Darboux vector and angular momentum, spherical images of a curve, applications in physics.
- Curves on a surface, tangent plane of a surface, metric of the surface, the meaning of Riemann geometry, properties of the first fundamental form, contravariant and covariant vectors, contravariant, covariant and mixed tensors, basic rules of tensor calculus, special tensors, normal on a surface, measures of angles on a surface, Area of a surface, second fundamental form, curvature of Gauss and mean curvature of a surface, Elliptic, parabolic and hyperbolic points of a surface, torus, Christoffel symbols, geodesics.
- Covariant derivative, Lie derivative, Levi-Civita transport, Einstein tensor, Tensor densities, deviation of geodesics, tidal forces, useful formulas, calculus of variation on the field theory, energy-momentum tensor, derivation of Einstein equations, applications in cosmology.

E3997. Chemistry (with laboratory)

- Atoms, periodic table of elements.
- Chemical bond, molecules, molecular interactions.
- States of matter.
- Chemical thermodynamics, chemical equilibrium, chemical kinetics.
- Solutions, acids, bases, oxidation-reduction.
- Elements of spectroscopy.

Specialization: **SOLID STATE PHYSICS AND MATERIALS**

Compulsory Specialization courses

CODE	COURSE TITLE	TYPE	TEACHING HOURS			ECTS
			Theory	Exercises	Lab	
Y3503	Quantum Optics and Lasers	COMSPE	2	2		6
Y3501	Solid State Physics I	COMSPE	2	2		6
Y3502	Solid State Physics II	COMSPE	2	2		6
Y3500	Solid State Physics Laboratory	COMSPE			3	3

Elective Specialization courses

CODE	COURSE TITLE	TYPE	TEACHING HOURS			ECTS
			Theory	Exercises	Lab	
E3512	Solid Earth Physics-Earthquake Dynamics	ELESPE	2	2		5
E3511	Physics of Molecules and Nanomaterials	ELESPE	2	2		5
E3514	Physics of Semiconductor Devices and Quantum Heterojunctions	ELESPE	2	2		5
E3515	Soft Matter Physics	ELESPE	2	2		5
E3513	Energy Conversion Devices	ELESPE	2		2	5

Y3503. Quantum Optics & Lasers

- Black body, Planck, Rayleigh-Jeans, Wien, and Stefan-Boltzmann laws.
- Electromagnetic waves (boundary conditions, cavity normal modes).
- Discrete spectrum, two-level system (atom, quantum dot, color center), stimulated-spontaneous absorption and emission mechanisms.
- Electromagnetic radiation of a two-level system (semiclassical description), dipole approximation, time-dependent perturbation theory, Rabi frequency, rotating wave approximation, allowed transitions.
- Electromagnetic radiation of a two-level system (quantum description), quantization of the electromagnetic field, spinors, commutators and anticommutators, transition dipole moment, photon absorption-emission, density matrix.
- LASER, pumping, population inversion, rate equations, longitudinal and transverse electromagnetic modes, types of lasers.

Y3501. Solid State Physics I

- Transport phenomena in metals, electrical and thermal conductivity (Drude, Lorenz, and Sommerfeld models), Boltzmann transport equation, temperature dependence of electrical conductivity.
- Energy bands, motion of electrons in a periodic potential, conductors, insulators and semiconductors, Bloch's theorem, the Kronig-Penney model.

- Semiconductor models, density of states in real materials, Fermi-Dirac statistics, equilibrium carrier distribution, doping, Fermi level, transport phenomena in semiconductors, drift, Hall effect, diffusion, band bending.

Y3502. Solid State Physics II

- Magnetism, diamagnetism and paramagnetism, origin of magnetic interactions, types of magnetic ordering, magnetic resonance.
- Superconductivity, general characteristics of superconductors, microscopic theory of superconductivity, the Josephson effect.
- Dielectric and optical properties of solids, fundamental properties of dielectrics, sources of polarizability, ferroelectricity.

Y3500. Solid State Physics Laboratory

- Electrons in a periodic potential.
- High-temperature superconductors.
- The p-n junction.
- Linear lattice vibrations.
- Relationship between electrical and thermal conductivity.
- Annealing of color centers in glass.

E3512. Solid Earth Physics - Earthquake Dynamics

- Thermal and pressure gradient in earth's interior. Equation of state of planets and correlation to inter-atomic potential of the constituting matter.
- Statistical mechanics of harmonic and anharmnic oscillators. Realistic potentials, thermal expansion, melting. Physics of extreme states of condensed matter.
- Elasticity, shear, point defects, line defects, dislocations.
- Dynamic properties, non-equilibrium statistical mechanics. Transition rate theory. Relaxation, diffusion, conductivity, viscosity. Homo- and heterogeneous disorder. Phonon assisted tunneling, Mott theory, fluctuation induced tunneling in granular structures.
- Heterogeneity, porosity, confined liquids and gases. Interfaces. Signals emitted prior to fracture and earthquake. Spectral content.
- The interior of large planets. Ultra-dense states of hydrogen. Wigner crystals under extreme compression, cold melting, metallic hydrogen.

E3511. Physics of Molecules and Nanomaterials

- Electronic structure of molecules, molecular binding, the hydrogen molecule, diatomic and polyatomic molecules (molecular orbitals, valence bond method), molecular orbitals hybridization and delocalization.
- Molecular spectroscopy, vibrational and rotational spectra of diatomic and polyatomic molecules, electronic transitions, Frank-Condon principle.
- Physics of nanomaterials, electronic structure of graphene and carbon nanotubes, electronic transitions, van Hove singularities.
- Imaging methods for nanomaterials, atomic force microscopy, tunneling microscopy, near-field optical microscopy.

E3508. Physics of Semiconductor Devices and Quantum Heterojunctions

- General characteristics of semiconductors, the p-n junction.
- Metal-semiconductor junction (Ohmic, Schottky).
- Heterojunctions, MIS and MOS junctions.
- Field effect transistor (JFET, MESFET).
- MOSFET transistor.
- Heterojunction, formation of quantum well, electrical and optical properties.
- Formation of quantum dots, electrical and optical properties.

E3515. Soft Matter Physics

- Introduction to soft matter, intermolecular interactions, interfaces, rheology, Brown motion, Langevin equation.
- Mesophases, order, disclinations, elasticity, anchoring, phase transitions, liquid crystal displays.
- Solutions, electrolytes, double layer, Poisson-Boltzmann theory, Debye-Huckel approximation.
- Colloids, DLVO theory, stabilization, kinetics, electrokinetic effects.
- Amphiphiles, micelles, self-organization, membranes, vesicles.
- Polymers, chain models, Flory - Huggens theory.
- Proteins, coil-globule and helix-coil transition.

E3513. Energy Conversion Devices

- Physics of photovoltaics.
- Thermoelectric effects and devices.
- Thermodynamic cycles, cooling devices (Joule-Thompson refrigerators).
- Magnetothermal effect, adiabatic demagnetization.
- Introduction to fuel cells and electrochemical devices.

Specialization: **NUCLEAR AND ELEMENTARY PARTICLE PHYSICS**

Compulsory Specialization courses

CODE	COURSE TITLE	TYPE	TEACHING HOURS			ECTS
			Theory	Exercises	Lab	
Y3404	Electromagnetism II	COMSPE	2	2		6
Y3406	Atomic and Molecular Physics	COMSPE	2	2		6
Y3402	Elementary Particles I	COMSPE	2	2		6
Y3403	Nuclear Physics I	COMSPE	2	2		6
Y3400	Nuclear Physics Laboratory	COMSPE			3	3

Elective Specialization courses

CODE	COURSE TITLE	TYPE	TEACHING HOURS			ECTS
			Theory	Exercises	Lab	
E3405	Mathematical Physics	ELESPE	2	2		5
E3415	Astroparticle Physics and Cosmic Rays	ELESPE	2	2		5
E3409	Medical Physics	ELESPE	2	2		5
E3414	Special Topics in Nuclear and Elementary Particle Physics	ELESPE	2	2		5
E3416	Modern Quantum Physics and Applications	ELESPE	2	2		5

Y3404. Electromagnetism II

- Applications of Maxwell's equations, electromagnetic potentials and Coulomb and Lorenz gauges.
- Maxwell's stress tensor, momentum conservation.
- Electromagnetic waves in dielectrics and conductors, dispersion.
- Waveguides, resonant cavities and optical fibers.
- Electromagnetic radiation, electric and magnetic dipole radiation (Lienard-Wiechert potentials, fields from moving charges).
- Radiation reaction.

Y3406. Atomic and Molecular Physics

- The hydrogen atom, the spin of electron and the interaction with an external magnetic field, coupling with orbital angular momentum, spectra, fine structure.
- Multi-electron atom, helium spectrum, Pauli's principle, Hartree theory, L-S coupling and J-J coupling, magnetic moments.
- Spectra of multi-electron atoms, interaction with an external field, multiple excitations, hyperfine structure, laser.
- Fundamental principles of molecular physics, Born-Oppenheimer approximation and two-atom molecules.
- The linear combination of atomic orbitals (LCAO), energy level diagram and molecular spectra, symmetries in molecules.
- Experimental methods in molecular spectroscopy.

Y3402. Elementary Particles I

- Introduction: Natural units, summary of elementary particles and interactions.
- Symmetries in particle physics: Groups SU(2) of spin and isospin, SU(3) of flavor and color, symmetries C και P, representations of SU(3), classification of mesons and baryons, magnetic moments of baryons.
- Non-relativistic quantum mechanics and antiparticles: Klein-Gordon equation, Dirac equation, free-particle solutions, antiparticles, massless fermions.
- Electromagnetic scattering: Non-relativistic scattering theory, Fermi's golden rule, spinless electron in electromagnetic field, electron-muon scattering, Feynman diagrams, scattering amplitude, cross section, electron with spin in electromagnetic field, Møller scattering.
- Weak interactions: Fermi's theory of β-decay, parity violation, the Wu experiment, unification of electromagnetic and weak interactions, W and Z bosons, Cabibbo angle, CKM matrix.

Y3403. Nuclear Physics I

- Nucleons and their interactions.
- Nucleon-nucleon strong interaction.
- Many-body quantum theory, models of nuclear structure.
- Experimental methodology and instrumentation in nuclear physics.
- Nuclear decays (α-, β-, γ-decay).
- Research fronts in contemporary nuclear physics, nuclear astrophysics.

Y3400. Nuclear Physics Laboratory

- Recording of hadronic and muonic component of cosmic radiation
- γ-γ angular correlation.
- Compton scattering.
- Environmental radioactivity.
- Real data analysis from LHC.

E3405. Mathematical Physics

- Green’s functions, Sturm-Liouville theory, initial value problems.
- Inhomogeneous boundary conditions.
- Eigenfunction expansion.
- Elements of group theory, finite and continuous groups, transformation groups and symmetries, subgroups, conjugacy class, factor groups.
- Representations, characters, Schur’s lemma, point symmetry groups, permutation group.
- Representations of rotation groups, SU(2) and SU(3).
- Numerical methods for the solution of Schrödinger’s equation, Numerov’s algorithm, finite-elements method, applications to discrete-spectrum problems.

E3415. Astroparticle Physics and Cosmic Rays

- Cosmology: Big-bang, early universe.
- CMB inflation.
- Nucleosynthesis, dark energy-matter.
- Cosmic rays: Hadronic and electromagnetic showers, neutrinos, γ-rays.

- Cosmic rays detection methods and devices: shower detection experiments.
- Recent experimental results: Hadronic showers, neutrinos, γ-rays, dark matter.

E3409. Medical Physics

- Radiation physics, production of ionizing and non-ionizing radiation, matter-radiation interaction.
- Biological effects of radiation, radiation protection, dosimetry.
- Medical imaging, diagnostic radiology, principles of computed tomography.
- Computed Tomography (CT), Single-Photon Emission Computed Tomography (SPECT), Positron Emission Tomography (PET).
- Non-ionizing imaging techniques: Magnetic Resonance Imaging (MRI), ultrasound imaging.
- Radiotherapy, brachytherapy, heavy-ion radiotherapy.

E3414. Special Topics in Nuclear and Elementary Particle Physics

- Strong interaction, introduction to hadronic physics, elements of quantum chromodynamics (QCD).
- Nucleon' and other hadron's phenomenology, deep inelastic scattering, parton model, distribution functions, other models and theories for hadron structure.
- Experimental methods and applications, basic detector instrumentation (gas-, scintillation-, semiconductor-, and neutron-detectors), multiwire detectors and thermidometry (determination of position, angle, electromagnetic cascade detectors, hadronic cascade thermidometry).
- Instrumentation for fixed-target scattering experiments.
- Applications (analytical methods, induced fusion and fission, biomedical applications).

E3416. Modern Quantum Physics and Applications

- Time-dependent perturbation theory, matter-radiation interaction, applications.
- Open quantum systems, density matrix.
- Quantum coherence-decoherence.
- Quantum entanglement, elements of measurement theory, EPR paradox, Bell inequalities.
- Elements of quantum information and quantum computers.

Specialization: **ASTROPHYSICS, ASTRONOMY** and **MECHANICS**

Compulsory Specialization courses

CODE	COURSE TITLE	TYPE	TEACHING HOURS			ECTS
			Theory	Exercises	Lab	
Y3104	Stellar Astrophysics	COMSPE	2	2		6
Y3102	Observational Astrophysics	COMSPE	2	2		6
Y3105	Plasma Astrophysics	COMSPE	2	2		6
Y3100	Advanced Astrophysics Laboratory	COMSPE			3	3

Elective Specialization courses

CODE	COURSE TITLE	TYPE	TEACHING HOURS			ECTS
			Theory	Exercises	Lab	
E3106	High Energy Astrophysics	ELESPE	2	2		5
E3108	Solar Physics	ELESPE	2	2		5
E3109	Space Physics	ELESPE	2	2		5
E3111	General Theory of Relativity and Cosmology	ELESPE	2	2		5
E3103	Non-linear Dynamical Systems	ELESPE	2	2		5
E3110	Stellar Systems and Galaxies	ELESPE	2	2		5

E3104. Stellar Astrophysics

- Stellar atmospheres.
- Radiative transfer and spectral formation.
- Stellar interiors.
- Life cycle of a star: Birth, evolution and death (white dwarfs, supernova remnants, neutron stars, black holes).

E3102. Observational Astrophysics (Techniques and Instrumentation)

- Coordinate systems, phenomena affecting the coordinates, time.
- Instruments used for the selection of radiation, telecopes in different parts of the electromagnetic spectrum: Optical telescopes, infrared telescopes, radio telescopes-radio interferometry, X-ray telescopes, γ-ray telescopes.
- Effect of the atmosphere (absorption, seeing, atmospheric compensation).
- Detection of radiation (basic principles, detection in different parts of the electromagnetic spectrum).
- Methods of astronomical observation and analysis: Photometry, spectroscopy, astrometry, polarimetry.
- Neutrino detectors.
- Cosmic ray detectors.
- Detection of gravitational waves.

E3105. Plasma Astrophysics

- Plasma ionization, Debye length, mean free path, plasma-Larmor-collision frequencies.
- Motion of electric charges in electromagnetic fields.
- Adiabatic invariants, magnetic mirror, applications: van Allen radiation belts, Earth- and planet-magnetospheres, space weather.
- Kinetic theory.
- Derivation of the basic equations of magnetohydrodynamics (MHD).
- MHD applications: Magnetic pressure, magnetic buoyancy, heating of the solar corona, dynamo theory for the generation of magnetic fields, magnetic reconnection, models of plasma structures in the laboratory, in space physics and in astrophysics (solar prominences, solar jets, coronal mass ejections, coronal loops, flares, etc).
- Solar wind and the model of E.N. Parker.
- Polytropic model for the solar wind, Mach-Bernoulli equations, critical point, solution topology, solar wind models with thermal conductivity.

E3100. Advanced Astrophysics Laboratory

- Introduction to space physics and space technology.
- Measurement of galactic dynamical and molecular mass using interstellar emission lines.
- Sagittarius A*: Determining the mass of the central black hole through the orbital characteristics of S stars.
- Simulations of astrophysical flows.
- N-body numerical simulations and galaxy formation.

E3106. High Energy Astrophysics

- Astrophysical high energy sources: Observations and physical processes.
- Inverse Compton scattering and applications.
- Synchrotron radiation and applications.
- Particle acceleration to high energies: Fermi mechanisms and acceleration in potential differences.
- Magnetohydrodynamic acceleration of relativistic astrophysical flows.
- Astrophysical accretion disks.

E3108. Solar Physics

- Sun: Basic characteristics.
- Solar interior: Core, radiation zone, convection zone.
- Solar atmosphere: Photosphere, chromosphere, transition region, corona.
- Quiet Sun: Granulation, supergranulation, limb darkering, chromospheric network, spicules, streamers, polar plumes, coronal condensations, coronal holes.
- Coronal heating.
- Solar magmetic field: Babcock theory, motion of particles in the solar magnetic field, magnetic loops, magnetic traps, magnetic mirrors.
- Solar plasma and magnetic field: MHD and magneto-hydrostatic approximation, reconnection of magnetic lines, current sheets.

- Active Sun: Active regions, faculae-plage, magnetic elements, pores, sunspots, filaments-prominences, flares, coronal mass ejections.
- Solar cycle and periodicities.

E3109. Space Physics

- Planetary magnetism, solar-terrestrial coupling, basic plasma properties, space plasma, charged particle motion in electric and magnetic fields, adiabatic invariants of motion, plasma waves.
- Solar wind: Parker theory, magnetic field, shock waves, CIR, ICMEs, fast and slow solar wind, interplanetary space.
- Heliosphere: Structure, variability, cosmic rays.
- Earth magnetosphere: Geomagnetic field, topology, plasma populations, sources and losses of plasma, open and closed magnetosphere models, magnetospheric disturbances, aurora.
- Explosive phenomena in geospace: Geomagnetic storms, magnetospheric substorms.
- Energetic particles in geospace: Ring current, van Allen radiation belts, acceleration and loss mechanisms, wave-particle interactions.
- Outer planets: Magnetosphere and satellites of Jupiter, magnetosphere of Saturn, rings and satellites of Saturn, magnetospheres of Uranus and Neptune.
- Inner planets: Magnetic field of Mars, ionosphere of Venus, magnetosphere of Mercury.
- Comets and small bodies in the heliosphere, principles of design and implementation of space missions, space instrumentation, analysis of spacecraft measurements.

E3111. General Theory of Relativity and Cosmology

- Tensors in linear spaces, manifolds, tensors in manifolds.
- Differentiation, torsion and curvature, covariant derivative, Lie derivative, Christoffel connection, Riemann curvature tensor, symmetries of geometrical objects.
- Einstein equation, energy-momentum tensor, weak gravitational fields.
- Symmetries (Killing fields), homogeneous spaces, spatial homogeneous space-times, Bianchi models.
- Spherical symmetric metric, Schwarzchild solution and its physical interpretation, observations, tests of general theory of relativity.
- Cosmology, the cosmological principle and the typical cosmological model.
- Friedmann-Robertson-Walker model, solutions, different eras in the universe evolution.

E3103. Non-linear Dynamical Systems

- Examples of nonlinear dynamical systems in nature, one-dimensional dynamical systems (stable and unstable fixed points).
- Qualitative analysis of nonlinear dynamical systems in two dimensions (fixed points and limit cycles).
- Poincaré-Bendixson theorem.
- Numerical integration of dynamical systems and study of its accuracy.

- Stability theory of fixed points and periodic orbits, propagators, Floquet theory.
- Lyapunov exponent, examples of chaotic systems.

E3110. Stellar Systems and Galaxies

- Variable stars.
- Binary stars: Formation and evolution.
- Interstellar medium: Regions of molecular, atomic and ionized hydrogen.
- Mass accretion: Compact X-ray systems
- Star clusters: Dynamical evolution, HR diagram.
- Our galaxy: Spiral structure and rotation.
- Galaxies: Formation and evolution, active galactic nuclei and quasars.

Specialization: **ENVIRONMENTAL PHYSICS – METEOROLOGY**

Compulsory Specialization courses

CODE	COURSE TITLE	TYPE	TEACHING HOURS			ECTS
			Theory	Exercises	Lab	
Y3304	Atmospheric Dynamics	COMSPE	2	2		6
Y3305	Atmospheric Boundary Layer Physics	COMSPE	2	2		6
Y3306	Air Quality	COMSPE	2	2		6
Y3300	Environmental Physics Laboratory	COMSPE			3	3

Elective Specialization courses

CODE	COURSE TITLE	TYPE	TEACHING HOURS			ECTS
			Theory	Exercises	Lab	
E3302	Physical Oceanography	ELESPE	2	2		5
E3305	Synoptic Meteorology	ELESPE	2		2	5
E3309	Climate-Climate Change	ELESPE	2	2		5
E3310	Renewable Energy Sources – Bioclimatic Design of Buildings	ELESPE	2	2		5

Y3304. Atmospheric Dynamics

- Basic concepts, forces, equations of motion, energy, mass conservation and simplified forms (incompressible, anelastic, Boussinesq) equation of state.
- Reference systems, coordinate systems, the pressure and potential temperature as vertical coordinate, pressure gradient.
- Characteristic scales of atmospheric motions, scale analysis, simplified forms of the basic equations, thermal wind, boundary layer and Ekman spiral.
- Vorticity, conservation of vorticity (absolute and relative), vorticity advection.
- Atmospheric stability (thermodynamic), dynamic stability/instability, small perturbations, Kelvin-Helmholtz, Raleigh-Taylor and Rossby waves.
- Taylor-Goldstein equation, internal and external gravity waves, acoustic and Lamb waves, wave trapping in the atmosphere.

Y3305. Atmospheric Boundary Layer Physics

- Introduction to viscous flows, laminar and turbulent flows, semi-empirical theories of turbulence.
- Soil heat transfer and soil temperatures.
- Turbulent kinetic energy, stability concepts.
- The homogeneous turbulent atmospheric boundary layer.
- The marine atmospheric boundary layer.
- Non-homogeneous atmospheric boundary layers.

Y3306. Air Quality

- Introduction to the structure and composition of the atmosphere, atmospheric boundary layer.
- Introduction to tropospheric chemistry, anthropogenic and natural sources of air pollution, tropospheric photochemistry and stratospheric chemistry.
- Estimation of air pollution – theory of air diffusion and dispersion – analytic solutions: Gauss equation, emissions.
- Atmospheric stability – instability.
- Introduction to air pollutants diffusion/dispersion model.
- Methodology for the measurement of air pollutants.
- Mechanisms for dry and wet deposition of air pollutants.
- Air quality in urban areas.
- Urban microclimate.

Y3300. Environmental Physics Laboratory

- Meteorological charts analysis.
- Vertical wind distribution.
- Mixing height calculation.
- Air pollution.
- Remote sensing in environmental studies.

E3302. Physical Oceanography

- Seawater properties, surface and vertical distribution of physical oceanography parameters in the world ocean.
- Conservation laws in physical oceanography.
- Currents without friction, shallow water equations and the conservation of vorticity in the ocean.
- Currents with friction: Wind-driven circulation, the Ekman surface layer and the westward intensification of ocean circulation.
- Thermohaline circulation.
- Surface gravity waves, internal waves, tides and ocean waves in the presence of rotation.
- Equatorial ocean dynamics.

E3305. Synoptic Meteorology (with laboratory)

- Vertical structure of atmosphere, atmospheric pressure, air masses.
- Fronts and frontal surfaces, associated weather phenomena.
- Depressions and anticyclones, associated weather phenomena.
- Surface weather charts, isobaric charts, thickness charts.
- Temperature advection, vorticity and vorticity advection, vertical motion.
- General circulation of the troposphere, jet streams, Rossby waves, blocking systems.
- Combined analysis of surface and isobaric charts, system movement.

E3309. Climate-Climate Change

- Planetary energy budget, general atmospheric circulation, hydrological cycle.
- Greenhouse gases and their role in climate, aerosol particles and their impact to radiative transfer.
- Coupling processes of the atmosphere-oceans-land.
- Natural variations of the atmosphere and the oceans, forcing mechanisms.
- Climate simulation models, basic set of partial differential equations, initial and boundary conditions, climate processes, feedback mechanisms.
- Global and regional climate, climate categorization.
- Climate variability and global climate (El Nino and Southern Oscillation – ENSO, North Atlantic Oscillation – NAO).

E3310. Renewable Energy Sources – Bioclimatic Design of Buildings

- Wind energy: Wind and characteristic parameters of wind, interaction of horizontal wind with the earth's surface, wind power equation, advantages-disadvantages.
- Solar energy: Solar radiation, active and passive solar systems, photovoltaics, applications.
- Biomass: Production, biomass sources and biomass conversion process, biomass products, advantages-disadvantages.
- Geothermal energy: Geothermal fields, applications of geothermal energy, environmental issues, advantages-disadvantages, applications.
- Hydroelectricity: Basic theory, characteristics of hydrothermal facilities, advantages-disadvantages, applications.
- Buildings: Bioclimatic design, active and passive systems, energy conservation, application of renewable systems in buildings.

Specialization: **Electronics, Computers, Telecommunications and Control**

Compulsory Specialization courses

CODE	COURSE TITLE	TYPE	TEACHING HOURS			ECTS
			Theory	Exercises	Lab	
Y3205	Signals and Systems	COMSPE	2	1	1	6
Y3201	Electronics II	COMSPE	2		2	6
Y3202	Computers II	COMSPE	2		2	6
Y3200	Electronics Laboratory	COMSPE			3	3

Elective Specialization courses

CODE	COURSE TITLE	TYPE	TEACHING HOURS			ECTS
			Theory	Exercises	Lab	
E3202	Automatic Control Systems	ELESPE	2	2		5
E3204	Introduction to Telecommunications Systems	ELESPE	2		2	5
E3201	Optoelectronics and Optical Communications	ELESPE	2	2		5
E3203	Microelectronics	ELESPE	2	2		5
E3207	Computer Systems	ELESPE	2	2		5

Y3205. Signals and Systems (with laboratory)

- Introduction to signals and systems.
- Convolution.
- Fourier analysis in the continuous time-domain and applications.
- Laplace transform: Properties and applications.
- Sampling.
- Fourier analysis in the discrete time-domain and applications.
- System simulations and applications in MATLAB.

Y3201. Electronics II (with laboratory)

- Power conversion/power supply.
- Wave shaping/wave shapers (linear, non-linear).
- Amplification/amplifiers, practical amplifying devices, operational models, performance characteristics of practical amplifiers.
- Basics of analysis/design of small signal amplifiers.
- Basics of analysis/design of large signal amplifiers.
- Basics of amplifier design for integrated circuits.
- Basics of analysis/design of digital functions, circuits and systems.

Y3202. Computers II (with laboratory)

- Computer arithmetic: 1's and 2's complement, floating point representation, addition/subtraction, methods for 2's complement multiplication, non/restoring division, convergence division.

- Computer architecture, combinatorial circuits: de/multiplexers, decoders, adders/subtractors, array multipliers, sequential circuits: Registers, counters, finite state machines.
- Computer organization: CPU, memory and peripheral organization, addressing modes, machine language, subroutines and stack.
- Theory and implementation in C code of the following data structures and algorithms: Lists, stacks, binary trees, merge, quick, heap.

Y3200. Electronics Laboratory

- Introduction to simulation tools of telecommunication systems, continuous and discrete signals, Fourier transform.
- Convolution, autocorrelation and correlation of signals.
- Continuous Fourier transform, sampling.
- Design, implementation and measurement of filters.
- Transverse Field Transistors
- Timing circuits
- Thyristor: Function and applications.

Y3202. Automatic Control Systems

- Basic concepts, Laplace and inverse Laplace transform, applications.
- Transfer function (of complex frequency), feedback, steady state errors.
- State equations (electrical, mechanical, electronic systems).
- Matrices, matrix exponential, solution of LTI systems in frequency and time domain.
- Stability (SISO open and closed loop systems, MIMO systems)
- Bode plots, phase lag and lead networks and design.
- Discrete time systems, Z-transform, inverse Z, stability.

Y3204. Introduction to Telecommunications Systems (with laboratory)

- General description of a telecommunication system.
- Analog modulations.
- Sampling and pulse modulations.
- Pulse code modulations.
- Digital modulation techniques.
- Propagation channel characteristics.
- Laboratory courses.

Y3201. Optoelectronics and Optical Communications

- Dispersion, anisotropic and nonlinear behavior in optical materials.
- Electrooptic modulators.
- Optical waveguides, multimode and monomode optical fibers, signal degradation effects.
- Structure and emission characteristics of LEDs and semiconductor lasers.
- Photoconductive detector, typical photodiode structures, phototransistor, MSM, photovoltaic cells.
- Optical communication system basics, optical networks.

Y3203. Microelectronics

- Development and fields of application in the realization of integrated circuits of silicon or compound semiconductors.
- Processes (crystal development, epitaxy, oxidation, doping via diffusion or ion implantation, metallization, lithography and subtractive processes).
- Structure of basic devices and physical design of integrated circuits.
- Application in the realization of logic gates and CMOS memory circuits.

Y3207. Computer Systems

- Types of operating systems, their structure, processes and system calls, processes and threads, process communication, semaphores, mutex, monitors, low level scheduling.
- Memory management, segments, virtual memory and paging, page replacement techniques, page size, thrashing and implementation issues.
- Directories, input/output, device handlers, and I/O software design principles.
- Deadlocks: Recovery and avoidance, security and cryptography principles, multiprocessor systems.
- Implementation in C and C++ code of relative example applications.

Student Practice Program

The “Student Practice Program” is implemented within the framework provided by the Operational Program “Education and Lifelong Learning”. It is co-funded by the European Union (European Social Fund) and national resources. The participating students are provided with two months of training, in private or civil services that offer internship positions. The specific criteria for selecting participating students can be found at the relative webpage of the Department for the “Student Practice Program”.

The participating students familiarize themselves with professional environments and are offered the opportunity to fulfill tasks that are directly related to their field of study. Additionally, they get acquainted with market trends and the required skills.

The program provides for the payment of the wages of the interns, as well as for their monthly insurance contributions, covering health and accident compensation costs. The students can undertake their internship locally in Athens, or in any other city in Greece, but accommodation costs are not covered.

Postgraduate Studies

Introduction

Postgraduate studies in Physics have been offered at the National and Kapodistrian University of Athens long before the establishment of the Physics Department as an independent entity within the School of Sciences in 1982. These postgraduate studies were originally offered either in the form of independent seminars and courses leading to a doctorate degree, or as structured postgraduate studies leading to a “Master’s Degree” in the research areas of “Electronics and Radioelectronics” (first offered in 1946), “Electronic Automation”(first offered 1972) and “Meteorology” (first offered in 1946). At the same time, in collaboration with the Departments of Biology, Geology and Chemistry a Master’s degree in “Oceanography”.

In 1994, the Physics Postgraduate Studies Program was re-established leading to MSc degrees in Physics. Since then, the MSc degrees of “Electronics and Radio Electronics” and “Electronic Automation” are inter-departmental postgraduate programs in collaboration with the Department of Informatics and Telecommunications of the National and Kapodistrian University of Athens, while the MSc in “Meteorology” was renamed to "MSc in Environmental Physics".

The curriculum of the Physics Postgraduate Studies Program has been updated three times (2002, 2014, and 2018) in order to keep up with current research developments.

Postgraduate Studies Program of the Department of Physics

The program of Postgraduate Studies of the Department of Physics currently offers:

- MSc Degree in "**Physics**" with the following three specializations (corresponding to three of the sections of the Department):
  1) Materials Physics
  2) Nuclear and Elementary Particle Physics
  3) Astrophysics

and

- MSc Degree in "**Applied Physics**" with the following specialization (corresponding to one of the sections of the Department).
  1) Environmental Physics

The duration of postgraduate studies leading to the MSc Degrees is three semesters. In order to obtain their MSc Degree, the graduate students are required to successfully complete three semesters that correspond to a total of 90 ECTS.

Attendance to courses is mandatory. Successful completion of each course requires a mark of 6 out of 10 in the corresponding examination.

In addition to courses and during the third semester, the student should undertake individually a research project leading to a MSc Diploma thesis, evaluated by a three-member committee. The final evaluation of the research thesis is responsibility of the corresponding Section of the MSc specialization.

Each student upon entering the postgraduate program is assigned a faculty member as his Advisor. The Advisor follows the progress of the student and consults the student on the selection of courses.

The presentation of the curriculum per semester is in the form of a table, showing the courses, the corresponding ECTS credits and the weekly hours for Theory-Exercises (Tutorial)-Laboratories.

Abbreviations:
COMCOR=compulsory core course,
COMSPE=compulsory specialization course,
ELECOR=elective core course,
ELESPE= elective specialization course,
SPETOP=Specific Topic (within the category ELESPE=elective specialization course)

MSc Degree in Physics with Specialization in Materials Physics

During the first two semesters, the student must successfully complete two out of five core courses offered: Electromagnetism, Quantum Physics, Mathematical Physics, Mechanics, Statistical Physics, two compulsory specialization courses: Electronic Structure and Properties of Matter and Advanced Laboratory, and additionally two of the specialization courses: Thermodynamics of Lattice Defects, Spectroscopic Methods for Materials Characterization, Physics of Semiconducting Devices, Physics and Technology of Materials, Physics of Earth's Solid Crust or the Specific topic within Materials Physics*:* Nanostructures and Biomaterials. During the third semester, the student should undertake individually a research project leading to an MSc Diploma thesis.

COURSE TITLE	TYPE	SEMESTER	TEACHING HOURS			ECTS
			Theory	Exercises	Lab	
1st SEMESTER						
two compulsory specialization courses						
Electronic Structure and Properties of Matter	COMSPE	A	3	1		10
Advanced Laboratory	COMSPE	A			4	10
one of the five core or specialization courses						
Quantum Physics	ELECOR	A	3	1		10
Mechanics	ELECOR	A	3	1		10
Mathematical Physics	ELECOR	A	3	1		10
Thermodynamics of Lattice Defects	ELESPE	A	3	1		10
Spectroscopic Methods for Materials Characterization	ELESPE	A	1		3	10
2nd SEMESTER						
three of the core, specialization or specific topic courses						
Electromagnetism	ELECOR	B	3	1		10
Statistical Physics	ELECOR	B	3	1		10
Physics of Earth's Solid Crust	ELESPE	B	3	1		10
Physics of Semiconducting Devices	ELESPE	B	3	1		10
Physics and Technology of Materials	ELESPE	B	3	1		10
Nanostructures and Biomaterials	SPETOP	B	3	1		10
3nd SEMESTER						
Compulsory						
MSc Diploma Thesis		C				30

MSc Degree in Physics with Specialization in Nuclear and Elementary Particle Physics

During the first two semesters, the student has to successfully complete two compulsory core courses: Electromagnetism and Quantum Physics, one of the compulsory specialization courses: Nuclear Physics and Physics of Elementary Particles, three of the core or specialization courses (one course could be from other MSc Degrees in Physics): Mathematical Physics, Mechanics, Experimental Methods in Physics, Quantum Theory of Fields, General Theory of Relativity, Cosmic Radiation, Statistical Physics, Computational Physics, Cosmology, or from the Specific topic within Nuclear and Elementary Particle Physics: Quantum Computing and Advanced subjects on Quantum Field Theory or one course from other MSc Degrees in Physics. During the third semester, the student should undertake individually a research project leading to an MSc Diploma thesis.

COURSE TITLE	TYPE	SEMESTER	TEACHING HOURS			ECTS
			Theory	Exercises	Lab	
1st SEMESTER						
one compulsory core course						
Quantum Physics	COMCOR	A	3	1		10
two of the five core or specialization courses						
Mechanics	ELECOR	A	3	1		10
Mathematical Physics	ELECOR	A	3	1		10
Experimental Methods in Physics	ELESPE	A	3	1		10
General Theory of Relativity	ELESPE	A	3	1		10
Cosmic Radiation	ELESPE	A	3	1		10
2nd SEMESTER						
one compulsory core course						
Electromagnetism	COMCOR	B	3	1		10
one of the two specialization courses						
Nuclear Physics	ELESPE	B	3	1		10
Physics of Elementary Particles	ELESPE	B	3	1		10
One core course and one specialization course or two specialization courses						
Electromagnetism	COMCOR	B	3	1		10
Statistical Physics	ELECOR	B	3	1		10
Computational Physics	ELESPE	B	3	1		10
Cosmology	ELESPE	B	3	1		10
Advanced subjects on Quantum Field Theory	SPETOP	B	3	1		10
Quantum Computing	SPETOP	B	3	1		10
3nd SEMESTER						
Compulsory						
MSc Diploma Thesis		C				30

MSc Degree in Physics with Specialization in Astrophysics

During the first two semesters, the student has to successfully complete the compulsory specialization course: Basic Topics in Astrophysics, two out of five core courses offered: Quantum Physics, Mechanics, Mathematical Physics, Electromagnetism, Statistical Physics, and additionally three (one course could be from other MSc Degrees in Physics) of the specialization courses: Observational Techniques and Data Analysis in Astronomy, Space Physics, Galactic and Extragalactic Astronomy, General Relativity and Cosmology, Computational Astrophysics, Non Linear Dynamics, Dynamical Astronomy, Space Systems and Space Weather, High Energy Astrophysics, Plasma Astrophysics, Solar Physics, Stellar Physics, Fluid Dynamics or from Specific topic within Astrophysics, Astronomy and Mechanics: Computational Astrophysics, Dynamical Astronomy, Stellar Structure and Nucleosynthesis. During the third semester, the student should undertake individually a research project leading to an MSc Diploma thesis.

COURSE TITLE	TYPE	SEMESTER	TEACHING HOURS			ECTS
			Theory	Exercises	Lab	
1st SEMESTER						
one compulsory specialization course						
Basic Topics in Astrophysics	COMSPE	A	3	1		10
two of the core or specialization courses						
Quantum Physics	ELECOR	A	3	1		10
Mechanics	ELECOR	A	3	1		10
Mathematical Physics	ELECOR	A	3	1		10
Observational Techniques and Data Analysis in Astronomy	ELESPE	A	3	1		10
Space Physics	ELESPE	A	3	1		10
Galactic and Extragalactic Astronomy	ELESPE	A	3	1		10
General Theory of Relativity	ELESPE	A	3	1		10
2nd SEMESTER						
three of the core or specialization courses						
Computational Astrophysics	SPETOP	B	3	1		10
Electromagnetism	ELECOR	B	3	1		10
Statistical Physics	ELECOR	B	3	1		10
Non Linear Dynamical Systems	ELESPE	B	3	1		10
Dynamical Astronomy	SPETOP	B	3	1		10
Space Systems and Space Weather	ELESPE	B	3	1		10
High Energy Astrophysics	ELESPE	B	3	1		10
Plasma Astrophysics	ELESPE	B	3	1		10
Solar Physics	ELESPE	B	3	1		10
Stellar Structure and Nucleosynthesis	SPETOP	B	3	1		10
Cosmology	ELESPE	B	3	1		10
3nd SEMESTER						
Compulsory						
MSc Diploma Thesis		C				30

MSc Degree in Applied Physics with Specialization in Environmental Physics

During the 3 semesters, the student has to complete successfully 7 compulsory specialization courses: Atmospheric Physics, Geophysical Fluid Dynamics, Methods of data analysis, Numerical Methods - Applications to Geophysical Fluid, Atmospheric Physics and Chemistry, Atmospheric Dynamics, Methods and instruments of environmental measurements, and 6 elective specialization courses: Atmospheric boundary layer, Synoptic Meteorology, Urban Environmental Physics, Climate - Climate Variations, Physical Oceanography, Principles and applications of Remote Sensing, Physics of the Middle and Upper Atmosphere, Atmospheric modeling, Environmental Management, Essentials of Soil Physics and surface Hydrology, Cloud Physics and Mesoscale Phenomena, Building Energy Design and Specific Topic within Environmental Physics-Meteorology. During the third semester, the student should undertake individually a research project leading to a MSc Diploma thesis.

COURSE TITLE	TYPE	SEMESTER	TEACHING HOURS			ECTS
			Theory	Exercises	Lab	
1st SEMESTER						
five compulsory specialization courses						
Atmospheric Physics	COMSPE	A	4			6
Geophysical Fluid Dynamics	COMSPE	A	4			6
Methods of Data Analysis	COMSPE	A	4			6
Numerical Methods - Applications to Geophysical Fluids	COMSPE	A	2		2	6
Atmospheric Physics and Chemistry	COMSPE	A	4			6
2nd SEMESTER						
two compulsory specialization courses						
Atmospheric Dynamics	COMSPE	B	3			5
Methods and Instruments of Environmental Measurements	COMSPE	B			3	5
four specialization courses						
Atmospheric Boundary Layer	ELESPE	B	3			5
Synoptic Meteorology	ELESPE	B	3			5
Urban Environmental Physics	ELESPE	B	3			5
Climate - Climate Variations	ELESPE	B	3			5
Physical Oceanography	ELESPE	B	3			5
Principles and Applications of Remote Sensing	ELESPE	B	3			5
Physics of the Middle and Upper Atmosphere	ELESPE	B	3			5
3nd SEMESTER						
two specialization courses						
Atmospheric Modeling	ELESPE	C	3			5
Environmental Management	ELESPE	C	3			5
Essentials of Soil Physics and Surface Hydrology	ELESPE	C	3			5
Cloud Physics and Mesoscale Phenomena	ELESPE	C	3			5
Building Energy Design	ELESPE	C	3			5
Specific Topic in Environmental hysics - Meteorology	SPETOP (ELESPE)	C	3			5
Compulsory						
MSc Diploma Thesis		C				20

Interdepartmental Programs of Postgraduate Studies

The Department of Physics participates in the following interdepartmental and interuniversity postgraduate programs:

1. The interdepartmental Postgraduate Program, in collaboration with the Department of Informatics and Telecommunications, leading to MSc Degrees in:
   - **Electronics and Radioelectrology**
   http://en.tomease.phys.uoa.gr/postgraduate-studies/electronics-and-radioelectrology/courses.html
   - **Control and Computing**
   http://en.tomease.phys.uoa.gr/postgraduate-studies/control-and-computing/courses-ha.html

   The recipients of these Degrees may continue their education towards a Doctoral Degree in one of the two Departments supporting the Program.

2. The interdepartmental Postgraduate Program in collaboration with the Departments of Biology, Geology and Geoenvironment, and Chemistry**:**
   - **Oceanography – Management of Marine Environment**
   http://oceanography.geol.uoa.gr/Frames/homepage.html

   This postgraduate program leads also to a Doctoral Degree.

3. The interuniversity Postgraduate Program in collaboration with the Schools of the National Technical University of Athens: Naval Architecture & Marine Engineering, Rural and Surveying Engineering, Applied Mathematical and Physical Sciences, Electrical and Computer Engineering and Mechanical Engineering, and the Hellenic Centre for Marine Research:
   - **Marine and Sea Technology and Science**
   http://www.naval.ntua.gr/graduate

4. The interuniversity – interdepartmental Postgraduate Program in collaboration with the Medical School of the National and Kapodistrian University of Athens, the Medical Departments of Aristotle University of Thessaloniki, University of Ioannina, Democritus University of Thrace, University of Crete as well as in cooperation with the Greek Atomic Energy Commission and the National Center for Scientific Research “Demokritos”:
   - **Medical Physics - Radiation Physics**

   http://medphys.med.uoa.gr/

5. The interuniversity – interdepartmental Postgraduate Program in collaboration with the Department of Informatics and Telecommunications of the National and Kapodistrian University of Athens, the Institute of Communications and Computer Systems and the Institute of Microelectronics of the National Center for Scientific Research “Demokritos”, and the Institut National Polytechnique de Grenoble:
   - **Microelectronics**
   http://cgi.di.uoa.gr/~vlsi/index.html

Doctoral Program

The Department of Physics awards a unified **Doctoral Degree (PhD) in Physical Sciences**.

The entry requirements for the doctorate program of the Department of Physics are (a) a graduate and (b) a postgraduate degree (MSc) in Physical Sciences from Greek Universities or Departments of Technical Universities, or from equivalent national or foreign University Departments recognized by the Hellenic National Academic Recognition Information Center (NARIC), or (c) a 5-year unified graduate degree in Physical Sciences or Engineering.

Applications are accepted in September, January and May of each year, following an announcement by the Department of Physics. In special occasions (e.g. related to a national call for research proposals) additional calls for applications may be announced.

Successful applicants are selected by the PhD Selection Committee (different for each area of research) and approved by the Department. A three-member advisory committee is nominated for each PhD student. One of the members of this committee is appointed as the doctoral thesis supervisor. At least one of the members of the committee must belong to the Faculty of the Department of Physics.

The PhD candidate provides detailed reports every year on his/her research work to the advisory committee. The advisory committee submits an annual progress report which is registered to the candidate's academic record held by the Secretariat of the Department of Physics. Failure to provide an annual report or a negative report by the advisory committee may lead to the dismissal of the candidate from the postgraduate program.

The minimum duration of the doctoral program is three full calendar years, starting from the date of the assignment of the advisory committee by the Department. The maximum duration of the doctoral studies is 5 years, with a possible extension by 1 year in very special circumstances.

The doctoral thesis can be written either in Greek or in English, accompanied by an extended abstract in English or in Greek, respectively, which will include the methodology, results and conclusions of the thesis.

Following its formal approval and recommendation by the advisory committee and the completion of the PhD candidate's obligations, the doctoral thesis is defended in public by the candidate before a seven-member examination board, including the three members of the advisory committee. The examination committee is assigned by the Department. The doctoral thesis is evaluated as: Excellent, Very Good, Good and Not Accepted by the examination board.

The ERASMUS+ Program

The Erasmus program subsidizes the mobility of undergraduate, graduate and doctoral level students from all university Departments, with the aim of allowing them to study for a period of time (usually one semester) at the European universities which have bilateral agreements in the context of the Erasmus+ program with the National and Kapodistrian University of Athens (NKUA, see http://en.interel.uoa.gr/). The bilateral agreements signed by the National and Kapodistrian University of Athens include, also, staff mobility for a short teaching period.

Universities collaborating with the Department of Physics (2018-2019)

Within the Erasmus+ program, the Department of Physics collaborates with universities in Europe that have concluded bilateral agreements of co-operation for the exchange of students from the three levels of studies (undergraduate, graduate and doctoral level). The exchange activities of the program supported by bilateral agreements, for the academic year 2018-2019, are shown in the table below.

Collaborating Universities/ partners	Academic coordinator responsible	Number of outgoing students*	Total Number of Student-months	Level of studies 1=undergraduate 2=graduate 3=doctoral	Primary language of courses
Rheinische Friedrich-Wilhelms-Universitat Bonn, Germany	KOURKOUMELI	6	30	1,2,3	EN (2,3)
Universite Grenoble Alpes, France	KOURKOUMELI	2	20	1.2	FR
Zachodniopomorski Uniwersytet Technologiczny w Szczecinie, Poland	KOURKOUMELI	3	30	1.2	EN
University of Zielona Gora, Poland	KOURKOUMELI	2	10	1,2,3	EN
Katholieke Universiteit Leuven, Belgium	MERTZIMEKIS	2	12	2	EN
University of Cyprus, Cyprus	MERTZIMEKIS	1	5	2	GR
Universita degli studi di Milano, Italy	MERTZIMEKIS	1	6	1,2,3	IT
Universite de Lille I, France	PAPATHANASIOU	2	20	1,2,3	FR

* The number of students supported by scholarships each year varies and is usually smaller than the numbers given in the table.

Incoming Students

The Department of European and International Relations of the National and Kapodistrian University of Athens daily provides information and every possible support to incoming students to facilitate their introduction and integration into the university community. At the beginning of each semester a reception ceremony is organized (Orientation Day) for the new incoming Erasmus students during which a general introduction to the University is given, information leaflets are distributed, as well as the required forms to be completed for their enrollment into the Departments

of the National and Kapodistrian University of Athens. The University Modern Greek Language Teaching Centre offers lessons in the Greek language to incoming Erasmus students and six credits (ECTS) are awarded after successful completion.

Outgoing Students

At the beginning of the spring semester the available fellowship positions (supported by the Greek National Scholarship Foundation https://www.iky.gr/en/) are announced and a call for applications is issued to the physics students who have completed at least their first year of studies. The applications are examined by the academic coordinator of each institution according to criteria previously announced. The selection results, together with the students' grading, are publicly announced on the Physics Department webpage. The selected/nominated students submit an application (both online and hardcopy) to the Department of European and International Relations of the National and Kapodistrian University of Athens, together with the necessary documents. Upon nomination, the names of the applicants are sent to the partner institutions and the students proceed to register with the foreign partner. An important part of the procedure is filling out the learning agreement, which is the main document for the recognition of the studies abroad.

Academic Recognition of Studies

Complete academic recognition of the period of study abroad is the main aim of the program and is attained as follows: Students choose, from courses offered by the receiving partners, the ones which correspond to the material taught by an "equivalent" course at the Physics Department. The outgoing students' program of studies must be equivalent to 30 credits ECTS for a semester-long period of study. The learning agreement is filled out with the help of the National and Kapodistrian University of Athens coordinator and is signed by both the National and Kapodistrian University of Athens and the foreign partner. Recognition of studies is provided within the framework of the agreement through the determination of the equivalence of these credits to those of courses within the home department, as long as the students pass successfully the courses at the receiving institution.

Information

More information and required documentation for the Erasmus+ program:
https://www.iky.gr/en/discover-erasmus
http://ec.europa.eu/programmes/erasmus-plus/node_en
http://en.interel.uoa.gr/erasmus/student-mobility.html
http://en.interel.uoa.gr/erasmus/student-mobility/application-procedure.html
http://en.interel.uoa.gr/erasmus.html
http://www.interel.uoa.gr/erasmus/sm/xrhsima-eggrafa.html
http://www.interel.uoa.gr/fileadmin/interel.uoa.gr/uploads/Odigos_diadikasion_gia_epilegmenoys_foitites_Erasmus__Spoydes_2016-2017.pdf

Erasmus+ Coordinator at the Department of Physics is Christina Kourkoumeli, Professor. tel:(+30) 2107276947, email: hkourkou@phys.uoa.gr

Modern Greek Language Teaching Centre

The Modern Greek Language Teaching Centre of the National and Kapodistrian University of Athens has been functioning since the 1950s, initially with a very limited number of students. In the decades that followed the number of students increased exponentially. The Modern Greek Teaching Centre is the largest of its kind in the world. Many of its graduates are today teachers of Modern Greek and Philology at Universities throughout the world, diplomats, church leaders, renowned scientists, company managers, respected artists and business professionals.

The Teaching Centre is under the auspices of the Interdepartmental Programme for the Teaching of Modern Greek as a second/foreign language along with the similarly titled Master's Degree Programme of the Department of Philology and the Department of Philosophy, Pedagogy and Psychology.

The aims of the Modern Greek Teaching Centre are as follows:

1. The teaching of Modern Greek as a second/foreign language;
2. The certification of the level of knowledge of Modern Greek as second/foreign language;
3. The exposure of foreigners to various facets and themes of Greek culture;
4. Hands-on practical training of students of the Master's Degree Programme for the Teaching of Modern Greek as a second/foreign language.

The courses of the Greek Language Teaching Centre are divided into levels of language knowledge in accordance with those of the Council of Europe. Once students have completed their course at any given level (A1, A2, B1, B2, C1 and C2), they will be in a position to understand, write and speak at the level they have reached by the end of the lessons.

The final level reached by the students depends on the amount of effort the student has put in and how much time was spent preparing and studying for the lessons.

Contact
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Telephone: (+30) 2107277672, 2107277971
Fax: (+30) 2107277673
E-mail: info@greekcourses.uoa.gr
Website: www.greekcourses.uoa.gr

Library of the School of Sciences

The Library's building is situated between the amphitheatre Aristotelis and the building of the Department of Mathematics. The Library's main entrance is close to the amphitheatre Aristotelis, whereas its secondary entrance is inside the building of the Department of Mathematics (on the 3rd floor corridor).

The Library has 4 reading rooms with a seating capacity of up to 550 people, 4 study rooms that can accommodate up to 6 people each, 1 computer room with 20 computers with free internet access for all Library's members, and 13 workstations on which all users can browse the Online Public Access Catalogue (OPAC) of the Libraries of the University of Athens (UoA).

The Library's book collection consists of 145.000 books with 92.000 individual titles, whereas the journal collection consists of 2080 titles. All this material is searchable online through the OPAC at:
http://www.lib.uoa.gr/ypiresies/katalogos-opac/

Conditions of use are available online on the Library's webpage (http://sci.lib.uoa.gr) and in printed form at all circulation and information desks.

Membership cards are issued in order to borrow books.

OPENING HOURS
Monday-Friday: 08.30 - 19.00
Saturday: 09.00 - 14.00
Tel. No.: (+30) 2107276599
Library's Secretariat: (+30) 2107276519
e-mails: sci@lib.uoa.gr, sci-loan@lib.uoa.gr (for loan renewals)
Address: Panepistimioupolis, Ilissia, GR-15703 Athens, Greece

Useful Online Platforms and Services

Registration to Secretariats' Management System

After acquiring the registration number in the Department of Physics, and during their studies, students are required to use the Secretariat's web management system of the Department of Physics in order to perform various actions. It is mandatory for every student to register following this link https://webadm.uoa.gr

Registration can be performed only once, and is completed in two stages: a) New account application and b) Account activation using PIN. After concluding the above procedure, students acquire a Username and a Password, both of which are permanent and secure access to the system, until the end of their studies. In order to interact with the Secretariat's website, students should use the above credentials.

Electronic Secretariat

This application can be accessed through any personal computer. Students can perform a variety of actions with comfort and ease. Specifically, students are able to:

1) Monitor, filter and print their grades.
2) Find information on every course of the Curriculum (teaching units, passing grade, weight factor, instructor, books etc.)
3) Register subjects of their interest.
4) Fill all the necessary applications provided by the Secretariat (transcript, conscription, tax office etc.). More information: https://my-studies.uoa.gr

Electronic Application for Student ID

A student ID is provided to undergraduate and postgraduate students. Each student qualifies for a reduced ticket price for all national means of transport. Students can receive their ID after applying online.
More information: http://academicid.minedu.gov.gr/

e-class

The e-class UOA platform is a Course Management System that supports modern eLearning services via a common web browser. Its goal is the incorporation and constructive use of the Internet and web technologies in the teaching and learning process. It supports the electronic management, storage and presentation of educational material, along with other teaching services, for each course.

Web Service for Textbooks

The Eudoxus system is a web service for the free provision of university textbooks to higher education students in Greece. Every semester, a student can acquire information, select and obtain one textbook for each course.
More information: http://eudoxus.gr

University Club

The University Club aims at improving the living conditions of the students of the University of Athens, their entertainment, and the enhancement of their social and cultural education, through procedures and initiatives for participation, socialisation and self-management. It includes the following sectors:

- Food supply
- Health care
- Gym
- Cultural society
- Students' Relief Fund

Contact
Address: 15, Ippokratous str. and Akadimias str., GR-10679 Athens
Telephone: (+30) 210368233, 2103688220, 2103688227, 2103688223
Fax: (+30) 2103688238

Students with Disabilities

The mission of the Accessibility Unit for Students with Disabilities of the National and Kapodistrian University of Athens is: to actively realize coequal access to academic studies for students with different abilities and needs, through built environmental modifications, assistive technologies and access services. The basic requirements of the students with disabilities include access to:

- Interpersonal communication with the members of the academic community
- The built environment of the university
- The printed or electronic educational material
- The board and the presentations in the classrooms
- The exams/tests
- The information and the WWW content.

The tutor Professor for Students with Disabilities for the Department of Physics is Niki Saoulidou (saoulid@phys.uoa.gr, tel. 2107276879)

More information:
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