United Arab Emirates University
Department of Physics
Graduate Courses

New name or number	Course level
PHYS 515 Methods of Mathematical Physics	UG,MSc, PhD
PHYS 525 Quantum Physics I	UG, MSc, PhD
PHYS 530 Electrodynamics I	UG, MSc, PhD
PHYS 541 Atomic Physics	UG, MSc, PhD
PHYS 542 Introduction to astrophysics	UG, MSc, PhD
PHYS 543 Laser Physics	UG, MSc, PhD
PHYS 545 Analytical Mechanics	UG, MSc, PhD
PHYS 552 Nuclear Physics	UG, MSc, PhD
PHYS 555 Introduction to Plasma Physics	UG, MSc, PhD
PHYS 560 Elementary Particle Physics	UG, MSc, PhD
PHYS 571 Radiation Physics	UG, MSc, PhD
PHYS 574 Physics of Radiotherapy	UG, MSc, PhD
PHYS 575 Physics of Semiconductors	UG, MSc, PhD
PHYS 576 Physics of Nuclear Medicine	UG,MSc, PhD
PHYS 578 Diagnostics Radiology	UG, MSc, PhD
PHYS 580 Biophysics	UG, MSc, PhD
PHYS 614 Modern Statistical Physics	MSc, PhD
PHYS 616 Experimental Condensed Matter Physics	MSc, PhD
PHYS 620 Quantum Physics II	MSc, PhD
PHYS 622 Solid-State Physics I	MSc, PhD
PHYS 625 Group and Representation Theory	MSc, PhD
PHYS 630 Electrodynamics II	MSc, PhD
PHYS 633 Seminar I	MSc, PhD
PHYS 635 General Relativity	MSc, PhD
PHYS 660 Methods in Experimental Particle Physics	MSc, PhD
PHYS 672 Medical Imaging and instrumentation	MSc, PhD
PHYS 675 Imaging Science	MSc, PhD
PHYS 678 Magnetic Resonance Imaging and Spectroscopy	MSc, PhD
PHYS 694 Seminar II	MSc, PhD
PHYS 698 Selected Topics I	MSc, PhD

Course Numbering System

(i) 500-599: Advanced undergraduate and graduate; pre-requisite of 90 credit hours earned for undergraduate students, completed any pre-requisite courses-or consent of department for undergraduates; **undergraduate and graduate credit.**

(ii) 600-699: Graduate standing and **graduate credit only**.

Course Description

PHYS 515 Methods of Mathematical Physics (3 CH)

Complex analysis, special functions with applications in Physics, calculus of variations, integral transforms, partial differential equations, boundary-value problems, Green's functions, operator algebra and tensors.
Prerequisite: Mathematical Physics (PHYS 255), or its equivalent.

PHYS 525 Quantum Physics I (3 CH)
Presents the basic concepts and mathematical formalism of quantum mechanics and introduces applications in atomic, molecular, and solid state Physics. Topics include the mathematics of quantum mechanics, one-dimensional problems, central field problems, the interaction of electromagnetic radiation with atomic systems, the harmonic oscillator, angular momentum, and perturbation theory.
Prerequisite: Quantum Mechanics (PHYS 355) or its equivalent

PHYS 530 Electrodynamics I (3 CH)
Electrostatics and magnetostatics, Electric and magnetic fields in matter, Boundary value problems in electrostatics and magnetostatics, Polarization and magnetization, Multipole expansion and dielectrics, Maxwell's equations, Conservation laws, Wave guides and resonators.
Prerequisite: Introduction to Electromagnetic Theory (PHYS 335), or its equivalent.

PHYS 541 Atomic Physics (3 CH)
Electronic structure of one-electron atoms; fine and hyperfine structures, Interaction of one-electron atoms with static external electric and magnetic fields and with electromagnetic radiation. Study of the electronic structure of many-electron atoms using Pauli Exclusion principle, perturbation and variational methods, angular momentum coupling schemes, central field approximation, Thomas-Fermi model, Hartee-Fock method, interactions of many-electron atoms with static and magnetic fields and electromagnetic radiation, Auger effect.
Prerequisite: Atomic Physics (PHYS 250), or its equivalent.

PHYS 542 Introduction to astrophysics (3 CH)
The course is intended as an introduction to the concepts of modern astrophysics for the advanced undergraduate students and graduate students. It covers topics such as celestial coordinate systems, celestial orbits, radiation, stars, stellar structure, stellar evolution, clusters of stars, galactic components, galactic structure, galaxy types, active galaxies and cosmology.
Prerequisite: Modern Physics (PHYS 250), or its equivalent.

PHYS 543 Laser Physics (3 CH)
Theory of laser operation, rate-equation, properties of laser beams, three-level and four-level systems, passive optical resonators, pumping process, single-mode and multi-mode lasers, transient laser behavior, relaxation oscillations, Q-switching, cavity-dumping, mode-locking, some specific laser systems and applications to medicine, material processing, laser-driven fusion and holography.
Prerequisites: Quantum Mechanics (PHYS 355), or its equivalent.

PHYS 545 Analytical Mechanics (3 CH)

Elementary principles, variational principles and Lagrange's equations, central force problem, kinematics of rigid body motion, oscillations, Hamilton's principle and Hamilton's equations, Canonical transformations, Hamilton-Jacobi theory, classical chaos, canonical perturbation theory, introduction to Lagrangian and Hamiltonian formulations for continuous systems and fields.
Prerequisite: Classical Mechanics (PHYS 262), or its equivalent.

PHYS 552 Nuclear Physics (3 CH)
Nuclear Properties (Nuclear Radius, Mass and Abundance of Nuclides, Nuclear Binding Energy), Forces between Nucleons (Properties of the Nuclear Force, The Exchange Force Model), Nuclear Structures and Nuclear Models (Liquid-drop Model and the Semi-empirical Mass Formula, Shell Model, More Realistic Nuclear Models), Nuclear Decay and Radioactivity, Nuclear Reactions (Fundamental Laws, Scattering and Reaction Cross Section, The Optical Model, Mechanisms of Nuclear Reactions), Neutron Physics (Neutron Sources, Absorption and Moderation, Neutron Reaction Cross Sections, Neutron Capture, Interference and Diffraction with Neutrons), Nuclear Fission (Characteristics of Fission, Energy in Fission, Fission Reactors, Radioactive Fission Products, Fission Explosives), Nuclear Fusion (Basic Fusion Processes, Characteristics of Fusion, Controlled Fusion Reactors, Thermonuclear Weapons).
Prerequisite: Quantum Mechanics (PHYS 355), or its equivalent.

PHYS 555 Introduction to Plasma Physics (3 CH)
This course will cover elementary plasma physics for physics and engineering students. It will include the following topics: The concept of temperature; the conditions of density and temperature necessary for the plasma state; discussion of fusion; motion of single charged particles in static and time varying electric and magnetic fields; plasmas described as (charged) fluids or magnetohydrodynamics; waves in plasmas; plasma heating with radio waves; kinetic theory description of plasmas including diffusion with and without magnetic fields; Debye shielding of a charge; Vlasov equation and collisionless plasmas; Landau dampening of waves; BGK single relaxation time model description of collisions; transport calculations of mass (diffusion); momentum (viscosity) and energy (heat conductivity).
Prerequisite: Electromagnetic Theory (PHYS 335).

PHYS 560 Elementary Particle Physics (3 CH)
Description of elementary particles with emphasis on phenomenology and historical and experimental buildup of current knowledge: weak decays and weak currents, parity violation, detectors and accelerators, elementary processes, deep inelastic scattering and proton model, quark model spectroscopy, color symmetry, elements of the Standard Model, successes and shortcomings.
Prerequisites: Quantum Physics I (PHYS 520), or its equivalent.

PHYS 571 Radiation Physics (3 CH)
Review of fundamentals of sources of radiation, nuclear Physics and radioactivity, and X-ray production. Interaction of heavy charged particles with matter, interaction of electrons with matter, linear energy transfer, interaction of photons with matter,

interaction of neutrons with matter, neutron fission and criticality, radiation detection, statistics, introduction to radiation dosimetry, radiation protection criteria and exposure limits.
Prerequisite: Modern Physics (PHYS 250), or its equivalent.

PHYS 574 Physics of Radiotherapy (3 CH)
Review of X-ray production and fundamentals of nuclear physics and radioactivity. Detailed analysis of radiation absorption and interactions in biological materials as specifically related to radiation therapy and radiation therapy dosimetry. Explore the use of computers and electronics in the diagnosis, tumor and normal tissue localization, treatment planning, treatment delivery, and treatment verification as applied to cancer patients; principles of radiation therapy treatment planning and isodose calculations. This is in addition to surveys of use of teletherapy isotopes and X-ray generators in radiation therapy plus the clinical use of interstitial and intracavitary isotopes (fundamentals of brachytherapy, and brachytherapy dosimetry systems). Problem sets taken from actual clinical examples are assigned.
Prerequisite: Radiation Physics (PHYS 382), or its equivalent.

PHYS 575 Physics of Semiconductors (3 CH)
This course gives students a solid background in semiconductor Physics and devices. It explains crystal structure, band structure and carrier statistics, carrier transport, phonons, scattering processes, electro- and optical- absorption in semiconductors.
Prerequisite: Solid state Physics (PHYS 471), or its equivalent.

PHYS 576 Physics of Nuclear Medicine (3 CH)
Physical bases of nuclear medicine are reviewed, and imaging instrumentation and computer diagnosis is discussed. Other topics include radionucleide generator systems and quality control, radiopharmaceutical preparations and quality control, chemistry and radiopharmacology of radionucleides, and radiopharmaceuticals for diagnostics and therapeutics. Unsealed source dosimetry, nuclear measurement instrumentation, spectrometry. This course also includes design and function of gamma cameras, single photon emission tomography, and positron emission tomography.
Prerequisite: Radiation Physics (PHYS 382), or its equivalent.

PHYS 578 Diagnostics Radiology (3 CH)
Course includes practical applications of diagnostic radiology for various measurements and equipment assessments. Topics include X-ray generator calibration, focal spot measurements, radiation output measurements, half-value layer measurements, and others. The description and design of computed tomographic systems as well as the associated reconstruction algorithms from single to multislice helical systems are studied.
Prerequisite: Radiation Physics (PHYS 382), or its equivalent.

PHYS 580 Biophysics (3 CH)
This course will explore topics in bio-electricity based on the classical theory of electricity and magnetism. Topics include: transport in an infinite medium, transport

through neural membranes, impulses in nerve and muscle cells, exterior potential and electrocardiogram, biomagnetism, electricity and magnetism at the cellular level.
Prerequisite: General Physics II (PHYS 1102), or its equivalent.

PHYS 614 Modern Statistical Physics (3 CH)
Review of the statistical theory of thermodynamics, Ensemble theory, identical particles. Quantum statistical Physics, Distribution functions, Applications to Quantum gases (superfluidity, superconductivity, and Bose-Einstein condensation), Critical phenomena, Brownian motion, Langevin, and Fokker-Planck and Boltzmann equations.
Prerequisite: Statistical Physics (PHYS 312), or its equivalent.

PHYS 616 Experimental Condensed Matter Physics (3 CH)
This course deals with experimental techniques (X-ray, Raman Spectroscopy, Electron Microscope, Auger Spectrometer, X-Ray Fluorescent, Electrical measurements, Magnetic measurements, Optical measurements, Positron Annihilation, etc) used for material characterizations and study of physical properties as well as defects of different materials. Particularly the course deals with phase transitions of amorphous and crystal compounds, Synthesis of composites, thin films, superlattices and nanomaterials.
Prerequisite: Modern Physics (PHYS 250), or its equivalent.

PHYS 620 Quantum Physics II (3 CH)
Variational theorem and WKB method, time-dependent perturbation theory, scattering theory, Born approximation, Identical particles and second quantization, symmetry principles, Dirac and Klein-Gordon equations for free particles, quantum theory of radiation, path integral formalism.
Prerequisite: Quantum Physics I (PHYS 520).

PHYS 622 Solid-State Physics I (3 CH)
crystalline structure and symmetry, Bravais lattice and reciprocal lattice, lattice vibrations and phonons, specific heat, energy band theory of metals, semiconductors and insulators, electric transport in metals and semiconductors, optical, dielectric, and magnetic properties, superconductivity.
Prerequisite: Quantum Mechanics (PHYS 355), or its equivalent.

PHYS 625 Group and Representation Theory (3 CH)
Group and representation theory designed for the particle physicist: groups and their representations: general theory and results; Lie Groups and their representations; Lie algebras and their representations; use and applications in Modern Physics.
Prerequisite: Quantum Physics II (PHYS 620).

PHYS 630 Electrodynamics II (3 CH)
Review of Maxwell's equations and the conservation laws, electromagnetic potentials, multipole radiation, radiation from moving charges, plane waves in material media,

polarization, attenuation, dispersion, diffraction, scattering, special relativity, Relativistic electrodynamics.
Prerequisite: Electrodynamics I (PHYS 530).

PHYS 633 Seminar I (1 CH)
This course is based on a research project where the student is expected to present a seminar at the end of the semester. The topic is selected by the faculty member.

PHYS 635 General Relativity (3 CH)
Introduction to Einstein's theory of General Relativity: a review of Special Relativity; the equivalence principle; tensor calculus and elements of differential geometry; Einstein's gravitational field equations; classic tests of General Relativity and standard applications in Astrophysics and Cosmology.
Prerequisites: Analytical Mechanics (PHYS 540) and Electrodynamics I (PHYS 530).

PHYS 660 Methods in Experimental Particle Physics: (3 CH)
This course is required for students preparing a doctoral thesis in experimental particle physics. Topics designed and taught by the various LHC collaborations (CMS, ATLAS, ALICE, etc.).
Prerequisite: Elementary Particle Physics (PHYS 560).

PHYS 672 Medical Imaging and instrumentation (3 CH)
This course covers the physical aspects of medical image formation. Image receptor design/optimization, reconstruction techniques, device hardware and performance characteristics are considered. This course includes a system theory approach to the production, analysis, processing and reconstruction of medical images. An extensive use of Fourier techniques is used to describe the processes involved with conventional radiographic detectors, digital and computed radiography.
Prerequisite: Mathematical Physics (PHYS 255), or its equivalent.

PHYS 675 Imaging Science (3 CH)
This is a general imaging course intended to: 1) cover the basic physical principles of image formation and contrast of the main imaging modalities; and 2) introduce their applications in disciplines such as medicine, biology, and chemistry. It is designed to be given for non-physics students and to explain elements of hardware, basic energy interaction leading to image formation, basic image properties including signal-to-noise ratio, resolution, and contrast, and finally sample and technical factors controlling image contrast. The main modalities include: x-ray imaging, computed x-ray tomography, magnetic resonance imaging (MRI) and spectroscopy (MRS), Nuclear Medicine (SPECT, PET Imaging). Functional and multi-dimensional imaging is also introduced.
Students may be asked to cover elementary topics according to their background.
Prerequisite: Modern physics (PHYS 250), or its equivalent.

PHYS 678 Magnetic Resonance Imaging and Spectroscopy (3 CH)

Basic physics of NMR, relaxation phenomena, relaxation time measurement, rotating reference frame and resonance, RF field, Bloch equations, magnetic field gradient, projection, basic pulse sequences, image contrast, one-dimensional Fourier imaging, k-space, slice excitation, multi-dimensional imaging; advanced MRI methods including fast imaging, chemical shift imaging, diffusion imaging, functional MRI, flow imaging, MR angiography, and cardiac gated imaging; hardware for MRI; radiofrequency coils, surface coils; in vivo NMR spectroscopy.
Prerequisite: Modern Physics (PHYS 250), or its equivalent.

PHYS 694 Seminar II (1 CH)
This course is based on a research project where the student is expected to present a seminar at the end of the semester. The topic is selected by the faculty member.

PHYS 698 Selected Topics I (3 CH)
This course is proposed by faculty members based on students' curricular needs and/or new trends in Physics