Physics

Applied Physics

The NJIT and Rutgers-Newark departments of physics offer a unique opportunity to pursue master's and doctoral degree physics in a joint program combining the resources of two of New Jersey's public research universities.

Interdisciplinary physics research is available in collaboration with faculties of NJIT, Rutgers-Newark and Rutgers-New Brunswick, and RBHSin areas such as device physics, materials research, ultrafast optical and optoelectronic phenomena, imaging technology, surface physics, free electron laser physics, biophysics, discharge physics, solar physics, and applied laser physics. Cooperative research efforts are underway with the National Renewable Energy Laboratory, National Solar Observatory, Lucent Technologies Bell Labs Innovations, U.S. Army Research Laboratory, and other industrial and federal research laboratories.

Master of Science in Applied Physics

The program is for students with an undergraduate degree in physics, applied physics, or engineering, who wish to apply physics to biological problems, optical science, microelectronics, device physics, materials science, solar cells, surface science, laser physics, solar phenomena, and other related areas.

Admission Requirements

A bachelor's degree in physics, applied physics, or related areas from an accredited institution is required. An undergraduate GPA above 3.0 is required. Students must submit GRE (general test) scores. In addition, applicants are required to provide letters of recommendation from their previous academic institutions. Students for whom English is not their native language are required to have TOEFL scores no lower than 550 (pencil and paper) and 213 (computer-based).

Doctor of Philosophy in Applied Physics

This program is for students in applied physics that are interested in and committed to scholarly research.

Admission Requirements

Applicants are expected to have a master's degree in physics, applied physics, or related engineering disciplines from an accredited institution. Highly qualified students with bachelor's degrees may be accepted directly into the doctoral program. A GPA of at least 3.5 in undergraduate and previous graduate studies is normally required for admission. The GRE (general test) and advanced (physics) test scores are required. Applicants are required to provide three letters of recommendation from their previous academic institutions. Students for whom English is not their native language are required to have TOEFL scores no lower than 550 (pencil and paper) and 213 (computer-based).

Materials Science and Engineering

This intercollegiate (CSLA and NCE), interdepartmental, and interdisciplinary degree program is intended for individuals with a strong background in science and/or engineering.

Master of Science in Materials Science and Engineering

Admissions Requirement

Applicants are expected to have an undergraduate degree from an accredited institution. A minimum undergraduate GPA of 3.0 on a 4.0 scale, or equivalent is normally required for admission. An undergraduate major in physics, chemistry, materials science, or a related engineering discipline is preferred. GRE quantitative scores of 700 or higher are highly desirable. Students from countries where English is not the native language should demonstrate TOEFL scores higher than 550 (pencil and paper) and 213 (computer-based).

Doctor of Philosophy in Materials Science and Engineering

This is an intercollegiate (CSLA and NCE), interdepartmental, and interdisciplinary degree program for superior students who wish to do advanced research in an area of materials science and engineering. Current areas of research include electronic and photonic materials, nano and particulate materials, polymer and biomaterials, and other areas of materials science and engineering.

Admission Requirements

Applicants are expected to have an appropriate master's degree in materials science or related field, physics, chemistry, or engineering from an accredited institution. Students entering with a master's degree must have at least a 3.5 GPA on a 4.0 scale in previous graduate study. Highly qualified students with bachelor's degrees may be accepted directly into the doctoral program. These students must have at least a 3.5 GPA in undergraduate work.

NJIT Faculty

A

Ahn, Keun Hyuk, Associate Professor

Ahn, Kwangsu, Assistant Research Professor

C

Cao, Wenda, Associate Professor

Chin, Ken K., Professor

Chen, Bin, Assistant Professor

D

Delahoy, Alan E., Research Professor

Deng, Na, Research Professor

Dias, Cristiano Luis, Assistant Professor

F

Farrow, Reginald C., Research Professor

Federici, John F., Distinguished Professor

Fleishman, Gregory David, Distinguished Research Professor

G

Gary, Dale E., Distinguished Professor

Gatley, Ian, Distinguished Professor

Georgiou, George E., University Lecturer

Gerrard, Andrew J., Professor

Gokce, Oktay Huseyin, Senior University Lecturer

Goode, Philip R., Distinguished Research Professor

J

Janow, Richard H., University Lecturer

Jerez, Andres, University Lecturer

Jing, Ju, Research Professor

K

Kosovichev, Alexander G., Professor

L

Lanzerotti, Louis J., Distinguished Research Professor

Levy, Roland A., Distinguished Professor

Liu, Chang, Research Professor

M

Maljian, Libarid A., University Lecturer

N

Nita, Gelu M., Research Professor

O

Opyrchal, Halina, Senior University Lecturer

P

Piatek, Slawomir, Senior University Lecturer

Prodan, Camelia, Associate Professor

R

Ravindra, N. M., Professor

Russo, Onofrio L., Associate Professor

S

Shneidman, Vitaly A., Senior University Lecturer

Sirenko, Andrei, Professor

T

Thomas, Benjamin, Assistant Professor

Thomas, Gordon A., Professor

Towfik, Nissim M., Associate Professor

Tyson, Trevor A., Distinguished Professor

V

Varsik, John R., Research Professor

W

Wang, Haimin, Distinguished Professor

X

Xu, Yan, Research Professor

Y

Yurchyshyn, Vasyl, Research Professor

Z

Zhou, Tao, Associate Professor

Programs

- Applied Physics - M.S. (http://catalog.njit.edu/graduate/science-liberal-arts/physics/applied-physics-ms/)
- Materials Science and Engineering - M.S. (http://catalog.njit.edu/graduate/science-liberal-arts/physics/materials-science-engineering-ms/)

Programs

- Applied Physics - Ph.D. (http://catalog.njit.edu/graduate/science-liberal-arts/physics/applied-physics-phd/)
- Materials Science & Engineering - Ph.D. (http://catalog.njit.edu/graduate/science-liberal-arts/physics/materials-science-engineering-phd/)

Physics Courses

MTSE 590. Grad Coop Work Exp I. 1 credit, 1 contact hour.

MTSE 591. Grad Coop Work Experience II. 1 credit, 1 contact hour.

MTSE 593. Graduate Co-op Work Experience IV. 0 credits, 0 contact hours.
Prerequisites: One immediately prior 3-credit registration for graduate co-op work experience with the same employer. Requires approval of departmental co-op advisor and the Division of Career Development Services. Must have accompanying registration in a minimum of 3 credits of course work.

MTSE 601. Fundamentals of Engineering Materials. 3 credits, 3 contact hours.
Prerequisite: graduate standing. Core course for students in Material Science and Engineering. The effect of structure on the properties and behavior of engineering materials. Topics include atomic structure, bonding, crystallography, and defects in solids; properties of metals, semiconductors, ceramics, and polymers and their behavioral response to mechanical, chemical, optical, electrical, and magnetic stimuli.

MTSE 602. Thermodynamics of Materials. 3 credits, 3 contact hours.
Prerequisite: undergraduate thermodyamics. Core course for students in Material Science and Engineering. Review of first, second, and third laws of thermodynamics and their applications to materials. Stability criteria, simultaneous chemical reactions, binary and multicomponent solutions, phase diagrams, surfaces, adsorption phenomena, thermochemistry of homogeneous and heterogeneous reactions are covered.

MTSE 603. Intro to Phys Prin of Material. 3 credits, 3 contact hours.
Introduction to physical principles useful to understand materials properties. Topics include Schrodinger equations, harmonic oscillators, observables, operators, angular momentum, hydrogen atom, atoms, matrix representation of operators, perturbation theory, molecules, metals, insulators, semiconductors, and low dimensional materials.

MTSE 610. Mechanical Properties of Materials. 3 credits, 3 contact hours.
Prerequisite: graduate standing. Elements of elasticity and plasticity theory, deformation and fracture behavior of materials, the concept of dislocations and their interaction with other lattice defects, strengthening mechanisms in solids, and principles of failure analysis. Materials to be studied include metals, polymers, ceramics, glasses, and composites.

MTSE 615. Composite Materials. 3 credits, 3 contact hours.
Prerequisites: MTSE 605 and MTSE 610. Introduction to fundamental principles of design and technology of composite materials. Materials based on polymer, ceramic, and metal matrices are discussed. Properties of the constitutive materials, their structure, methods of structural arrangements, as well as properties and characterization of the final products are described. The different perspectives, examples, and problems in composite applications are outlined.

MTSE 619. Nano-scale Characterization of Materials. 3 credits, 3 contact hours.
The course presents the basics of nanotechnology and the principles and application of advanced instrumentation for the characterization of nanostructures. Topics include atomic force microscopy, near-field optics, dielectric spectroscopy, and light scattering. The significant component of the course is laboratory work at the W. M. Keck Foundation Laboratory and research project.

MTSE 625. Introduction to Ceramics. 3 credits, 3 contact hours.
Prerequisite: MTSE 605. Mechanical, thermal, electrical, magnetic, and optical properties of crystalline and glassy ceramics are discussed from a structural viewpoint. Important processing methods, design and evaluation of properties, and modern applications of ceramic materials are emphasized.

MTSE 627. Glass Science and Engineering. 3 credits, 3 contact hours.
Prerequisites: MTSE 605 and MTSE 630. Formation and structure of inorganic, polymeric, and metallic glasses. Transport phenomena, kinetics of crystallization, glass transition, and phase separation; chemical, mechanical and optical properties of glasses.

MTSE 630. Thermodynamics of Materials. 3 credits, 3 contact hours.
Prerequisite: undergraduate thermodyamics. Review of first, second, and third laws of thermodynamics and their applications to materials. Stability criteria, simultaneous chemical reactions, binary and multicomponent solutions, phase diagrams, surfaces, adsorption phenomena, thermochemistry of homogeneous and heterogeneous reactions are covered.

MTSE 650. Physical Metallurgy. 3 credits, 3 contact hours.
Prerequisite: MTSE 605. Processing-structure-property relationships in metallic alloys. Alloy systems covered include carbon steels, stainless steels, aluminum and titanium alloys, and super alloys. Topics to be presented include elementary theory of metals, defects and related phenomena, solidification, phase phenomena, solid state diffusion, nucleation and growth kinetics, as well as transformation and deformation processes.

MTSE 655. Diffusion and Solid State Kinetics. 3 credits, 3 contact hours.
Prerequisite: MTSE 630. The atomic theory of diffusion and mathematical derivation of the diffusion equations. Diffusion phenomena in dilute alloys as well as in ionic and covalent solids are considered. High atom mobility effects at defect sites and surfaces are examined. Chemical kinetics and kinetics of phase transformations including nucleation, growth, and spinodal decomposition are discussed.

MTSE 681. Composite Materials. 3 credits, 3 contact hours.
Prerequisites: MTSE 601 and MTSE 610. Introduction to fundamental principles of design and technology of composite materials. Materials based on polymer, ceramic, and metal matrices are discussed. Properties of the constitutive materials, their structure, methods of structural arrangements, as well as properties and characterization of the final products are described. The different perspectives, examples, and problems in composite applications are outlined.

MTSE 682. Introduction to Ceramics. 3 credits, 3 contact hours.
Prerequisite: MTSE 601. Mechanical, thermal, electrical, magnetic, and optical properties of crystalline and glassy ceramics are discussed from a structural viewpoint. Important processing methods, design and evaluation of properties, and modern applications of ceramic materials are emphasized.

MTSE 685. Physical Metallurgy. 3 credits, 3 contact hours.
Prerequisite: MTSE 601. Processing-structure-property relationships in metallic alloys. Alloy systems covered include carbon steels, stainless steels, aluminum and titanium alloys, and super alloys. Topics to be presented include elementary theory of metals, defects and related phenomena, solidification, phase phenomena, solid state diffusion, nucleation and growth kinetics, as well as transformation and deformation processes.

MTSE 687. Glass Science and Engineering. 3 credits, 3 contact hours.
Prerequisites: MTSE 601 and MTSE 602. Formation and structure of inorganic, polymeric, and metallic glasses. Transport phenomena, kinetics of crystallization, glass transition, and phase separation; chemical, mechanical and optical properties of glasses.

MTSE 688. Mathematical and Statistical Methods in Materials Science. 3 credits, 3 contact hours.
Prerequisites: MATH 111, MATH 112 and (MATH 211 or MATH 213). The course introduces mathematical methods necessary for materials science with emphasis on practical applications. Topics include power series, complex numbers, linear algebra, partial differentiation, multiple integrals, vector analysis, Fourier series and transformation, ordinary and partial differential equations, functions of complex variables, probability, and statistics.

MTSE 690. Directed Study in Materials Science and Engineering. 3 credits, 3 contact hours.
Prerequisite: As specified by the instructor. Directed study at the Master's level under the guidance of a faculty member on a topic in materials science and engineering.

MTSE 700B. Master's Project. 3 credits, 3 contact hours.
Approval of the project advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in materials science. A written report must be submitted to the project advisor. The student cannot register in MTSE 700B more than once and the incomplete (I) grade is not allowed. Master’s students registering for the first time in Master’s Project must take simultaneously the INTD 799 (Responsible Contact of Research) course.

MTSE 701B. Master's Thesis. 3 credits, 3 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in materials science that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student is expected to defend the thesis upon accrual of six thesis credits. Additional registration in MTSE 701B, beyond six credits, is required every semester until successful thesis defense (six credits count toward degree requirements and time limits apply). Master’s students registering for the first time in Master’s Thesis must take simultaneously the INTD 799 (Responsible Contact of Research) course.

MTSE 701C. Master's Thesis. 6 credits, 6 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in materials science that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student must continue registering for three thesis credits (MTSE 701B) each semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

MTSE 702. Characterization of Solids. 3 credits, 3 contact hours.
Current methods for characterizing the chemical composition, crystallographic structure, electrical mapping, and morphology of solid materials. Principles and application of Auger Electron Spectroscopy (AES), Secondary Ion Mass Spectroscopy (SIMS), X-ray Photoelectron Spectroscopy (XPS), X-ray Emission Spectroscopy (XES), and Rutherford Backscattering Spectroscopy (RBS) for chemical analysis, X-ray Diffraction (XRD) and electron diffraction for crystallographic analysis, Electron Beam Induced Current (EBIC) microscopy, voltage contrast microscopy, Cathodoluminescence for electrical mapping, and Atomic Force Microscopy (AFM), Transmission Electron Microscopy (TEM), Scanning Electron Microscopy (SEM) and Nomarski interference contrast microscopy (DIC) for morphology.

MTSE 719. Physical Principles of Characterization of Solids. 3 credits, 3 contact hours.
Core course for students in Material Science and Engineering, Nano-scale characterization of materials. Basic science behind solid state characterization. Elements of modern physics. Optical microscope. Neutron scattering. Infrared and Raman spectroscopy. Rutherford backscattering spectroscopy. NMR. X-ray diffraction. X-ray photoelectron spectroscopy and Auger Electron Spectroscopy. SEM, TEM, STEM and STM.

MTSE 722. Science and Technology of Thin Films. 3 credits, 3 contact hours.
Prerequisite: graduate standing. Methods of preparing thin films by physical and chemical means are examined. Topics pertinent to nucleation and growth mechanism of single and polycrystalline films, structure determination, film thickness and compositional evaluation properties are discussed. The electrical, magnetic, optical, and mechanical properties of metallic, semiconductor, and insulating thin films are studied with particular relevance to integrated circuit applications.

MTSE 723. Defects in Solids. 3 credits, 3 contact hours.
Prerequisites: MTSE 601 and MTSE 725. Crystallographic defects in solids, namely point defects such as vacancies and interstitial, line defects such as dislocations, and planar defects such as grain boundaries. Correlation of these defects to the mechanical, electrical and optical behavior of materials is examined in particular. Experimental methods for observation and characterization of defects including TEM, EBIC, DLTS are described.

MTSE 724. Transport of Electrons and Phonons in Solids. 3 credits, 3 contact hours.
Prerequisite: PHYS 687 or R755 687. Basic transport processes involving electrons and phonons in solids. Topics inlcude transport-related phenomena such as Hall effect, quantum Hall effect, magneto-resistance, size effects, thermal conductivity, thermoelectric effects, phonon drag, ballistic phonons, and ballistic electrons. Applications of transport to the characterization of new electronic materials including thin films are stressed.

MTSE 725. Independent Study I. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once.

MTSE 726. Independent Study II. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once. Students should only register for MTSE 726 if they have taken MTSE 725 in a prior semester.

MTSE 737. Transport of Electrons and Phonons in Solids. 3 credits, 3 contact hours.
Prerequisite: PHYS 687 or R755 687. Basic transport processes involving electrons and phonons in solids. Topics inlcude transport-related phenomena such as Hall effect, quantum Hall effect, magneto-resistance, size effects, thermal conductivity, thermoelectric effects, phonon drag, ballistic phonons, and ballistic electrons. Applications of transport to the characterization of new electronic materials including thin films are stressed.

MTSE 757. Defects in Solids. 3 credits, 3 contact hours.
Prerequisites: MTSE 605 and MTSE 725. Crystallographic defects in solids, namely point defects such as vacancies and interstitial, line defects such as dislocations, and planar defects such as grain boundaries. Correlation of these defects to the mechanical, electrical and optical behavior of materials is examined in particular. Experimental methods for observation and characterization of defects including TEM, EBIC, DLTS are described.

MTSE 765. Science and Technology of Thin Films. 3 credits, 3 contact hours.
Prerequisite: graduate standing. Methods of preparing thin films by physical and chemical means are examined. Topics pertinent to nucleation and growth mechanism of single and polycrystalline films, structure determination, film thickness and compositional evaluation properties are discussed. The electrical, magnetic, optical, and mechanical properties of metallic, semiconductor, and insulating thin films are studied with particular relevance to integrated circuit applications.

MTSE 780. Current Topics in Materials Science and Engineering. 3 credits, 3 contact hours.
Prerequisites: As specified by the program for the semester's offering. Topics of current interest in materials science and engineering.

MTSE 788. Appl Comp Meth-Phys & Matls II. 3 credits, 3 contact hours.

MTSE 790A. Doctoral Dissertation. 1 credit, 1 contact hour.
Co-requisite: MTSE 791. Approval of the dissertation advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in materials science. For PhD students who have successfully defended their dissertation proposal. The student must register in MTSE 790A every semester until successful dissertation defense. A written dissertation must be defended and approved by a committee of at least five members. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint PhD programs with other universities).

MTSE 791. Graduate Seminar. 0 credits, 1 contact hour.
Required of all students enrolled in the M.S. or Ph.D. Program in Materials Science and Engineering. Faculty, students, and invited speakers will present and discuss current topics of research in materials science and engineering.

MTSE 792B. Pre-Doctoral Research. 3 credits, 3 contact hours.
Co-requisite: MTSE 791. Approval of the dissertation advisor is required for registration. Preliminary experimental and/or theoretical investigation of a relevant topic in materials science. For students who have passed the qualifying examination but have not defended the dissertation proposal. Permission is needed of the academic advisor as well for students who have completed the required coursework but have not passed the qualifying examination.

PHYS 590. Graduate Coop Work Exp I. 1 credit, 1 contact hour.

PHYS 591. Graduate Coop Work Exp II. 1 credit, 1 contact hour.

PHYS 607. Topics in Astronomy and Cosmology. 3 credits, 3 contact hours.
Prerequisites: college-level physics and mathematics. A survey of recent progress in astronomy, the physical principles involved, and the impact these new discoveries have on our understanding of the universe. Includes results from recent and ongoing planetary probes of our solar system, discovery of planetary systems around other stars, the evolution of stars, exotic objects such as neutron stars and black holes, the formation of galaxies, and current understanding of the birth and final fate of the universe. Observing sessions familiarize students with the sun, moon, and night sky.

PHYS 611. Adv Classical Mechanics. 3 credits, 3 contact hours.
Restrictions: Permission of the course instructor (Equivalent undergraduate junior- or senior-level coursework required at a B or higher grade).

PHYS 621. Classical Electrodynamic. 3 credits, 3 contact hours.
Restrictions: Permission of the course instructor (Equivalent undergraduate junior- or senior-level coursework required at a B or higher grade).

PHYS 641. Statistical Mechanics. 3 credits, 3 contact hours.

PHYS 652. Fund of Optical Imaging. 3 credits, 3 contact hours.
Prerequisites: PHYS 621 (Classical Electricity and Magnetism I) This is designed as a principal course of introducing optical engineering to master students in applied optics. The goal is to help students acquire the practical technical knowledge on optical systems and their design. The general approach throughout the course is to emphasize the application of basic optical principles to practice. Topics include general principles of geometric and physical optics, elemental geometric optics under paraxial ray approximation, aberrations, prisms and mirrors, the eye, stops and apertures, optical materials and interference coating, radiometry and photometry, basic optical devices, optical computation, image evaluation and optical system design, particularly computer aided designs.

PHYS 661. Solid-State Physics. 3 credits, 3 contact hours.
Properties of solid state materials are explained based on principles of physics. Electronic, magnetic, thermal, optical, and lattice properties of materials are studied. Various experimental and theoretical approaches are introduced.

PHYS 681. Solar Phys & Instrumentn. 3 credits, 3 contact hours.

PHYS 682. Introduction To Mems. 3 credits, 3 contact hours.

PHYS 687. Physics of Materials. 3 credits, 3 contact hours.
Prerequisite: PHYS 441 or equivalent (see undergraduate catalog for description). Fundamentals of quantum mechanics; energy bands in crystals; electrical conduction in metals and alloys, semiconductors; optical properties of materials; quantum mechanical treatment of optical properties; magnetic properties of materials; thermal properties, heat capacity, and thermal expansion in solids.

PHYS 688. Mathematical and Statistical Methods in Materials Science. 3 credits, 3 contact hours.
More emphasis on analytical methods and statistics. Course will be required for Ph.D. students in Materials Science.

PHYS 690. Directed Study Appl Phys. 3 credits, 3 contact hours.

PHYS 698. ST:. 3 credits, 3 contact hours.

PHYS 700. Master'S Project. 3 credits, 3 contact hours.
Prerequisite: Written approval from graduate advisor. For students admitted to the Master of Science program in applied physics who do not take Phys 701 Master's Thesis. An extensive paper involving experimental or theoretical investigation of a topic in microelectronics or other applied physics area is required. Cooperative projects with industry or government agencies may be acceptable. The project is carried out under the supervision of a designated physics graduate faculty member.

PHYS 700B. Master's Project. 3 credits, 3 contact hours.
Approval of the project advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in applied physics. A written report must be submitted to the project advisor. The student cannot register in PHYS 700B more than once and the incomplete (I) grade is not allowed. Master’s students registering for the first time in Master’s Project must take simultaneously the INTD 799 (Responsible Contact of Research) course.

PHYS 701B. Master's Thesis. 3 credits, 3 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in applied physics that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student is expected to defend the thesis upon accrual of six thesis credits. Additional registration in PHYS 701B, beyond six credits, is required every semester until successful thesis defense (six credits count toward degree requirements and time limits apply). Master’s students registering for the first time in Master’s Thesis must take simultaneously the INTD 799 (Responsible Contact of Research) course.

PHYS 701C. Master's Thesis. 6 credits, 6 contact hours.
Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in applied physics that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student must continue registering for three thesis credits (PHYS 701B) each semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

PHYS 721. Classical Electrodynamics II. 3 credits, 3 contact hours.
Prerequisite: PHYS 621 or equivalent; basic knowledge of tensor analysis. Simple radiating systems, scattering and diffraction; special theory of relativity; dynamics of relativistic particles and electromagnetic fields; collisions between charged particles, energy loss, and scattering; radiation from accelerated charge, synchrotron radiation, and bremsstrahlung.

PHYS 725. Independent Study I. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once.

PHYS 726. Independent Study II. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once. Students should only register for PHYS 726 if they have taken PHYS 725 in a prior semester.

PHYS 728. Radio Astronomy. 3 credits, 3 contact hours.
Prerequisites: PHYS 621 and PHYS 641 or the equivalent, or approval of the instructor. An introduction to radio emission processes, radiative transfer, radio diagnostics, and radio instrumentation. Topics include radio flux measurements with single antenna, radio imaging with interferometer arrays (Fourier Transform imaging), and image reconstruction techniques (CLEAN, MEM). Application is to astronomical objects with special emphasis on the Sun.

PHYS 731. Quantum Mechanics II. 3 credits, 3 contact hours.
Prerequisite: PHYS 631 or equivalent. Review of quantum mechanics and theory of special relativity; second quantization; relativistic one-particle problem; Klein-Gordon equation and Dirac equation; canonical field theory; relativistic scattering theory; introduction to quantum electrodynamics and quantum field theory; Feynman diagrams and applications.

PHYS 741. Basic Plasma Phys w Space, Lab. 3 credits, 3 contact hours.
Prerequisites: PHYS 611, PHYS 621, other equivalent, or approval of the instructor. Corequisites: PHYS 611, PHYS 621. The course will introduce students to basic concepts of plasma physics and its applications to laboratory experiments and space research. The course will cover the following topics: particle motions in magnetic field, adiabatic invariants, magnetic traps, radiation belts, electromagnetic waves in plasma, electrostatic oscillations, waves in magnetized plasma, collisional processes in plasma, kinetic effects on plasma waves, Landau damping, wave instabilities, plasma as fluid, magnetohydrodynamics, magnetic configurations of laboratory and space plasma, MHD instabilities, reconnection, helicity, dynamo theories, the origin of cosmic magnetic fields, stochastic processes, Fermi process, particle acceleration, and cosmic rays.

PHYS 747. Intro to Helioseismology. 3 credits, 3 contact hours.
Prerequisites: PHYS 611, PHYS 621 or other equivalent. The course will introduce the physical principles and methods to study wave oscillations, and the interior structure of the Sun. The course covers processes of acoustic and gravity wave excitation and propagation, interaction with turbulence and magnetic fields, oscillation spectrum, sunquakes, inferences of the structure and composition, the differential rotation, large-scale flows and meridional circulation. It includes the theory of normal modes, inversion techniques, wave dispersion analysis, acoustic tomography and holography, applications to the solar dynamo and magnetic activity.

PHYS 751. Applied Optics. 3 credits, 3 contact hours.
Prerequisites: PHYS 621 (Classical Electricity and Magnetism I) The course will introduce students to basic concepts of applied optics, light propagation and light and matter interactions. The course will cover the following topics: light propagation through mirrors and lenses, matrix optics, basic concepts of wave optics, reflection, refraction and transmission, equations governing wave propagation, Gaussian beams, Maxwell's equations, absorption, dispersion, light polarization states, temporal and spatial coherences.

PHYS 753. Light Sources & Photodetectors. 3 credits, 3 contact hours.
Prerequisites: PHYS 621 and PHYS 631. This is a survey course on theory and practical aspects of light sources and photodetectors. The specific light sources covered will be: black body, discharge tubes, X-ray, light.

PHYS 774. Fundamentals of Spectroscopy. 3 credits, 3 contact hours.
The major objectives of this course are to integrate theory and practice and to bring together different branches of Academic Studies and Industrial Research through the presentation of critical aspects of modern Spectroscopy. The course will provide a valuable theoretical introduction and an overview of modern topics in spectroscopy, which are of current interest and importance in Semiconductor Industry and Biomedicine. A wide range of techniques is considered, including optical Near field spectroscopy, X-ray, Raman, Neutron scattering, and FT-IR spectroscopy.

PHYS 780. Curr Topics Applied Phys. 3 credits, 3 contact hours.

PHYS 787. New Concepts of Semiconductor. 3 credits, 3 contact hours.
Prerequisite: PHYS 687 and ECE 657. This is an advanced course on semiconductor physics targeted at describing polycrystalline materials, e.g. cadmium telluride or copper indium diselenide, that are currently used in thin-gilm photovoltiac panels. An overview of classical semiconductor and solar cell theory is followed by topics such as non-shallow dopants, multi-level defects, defect transition energy level, and metastability. These concepts are applied to examine minority carrier lifetime and carrier collection in devices, and to extend the theories of admittance and deep level transient spectroscopy.

PHYS 789. Physics of Advanced Semiconductor Device Processing. 3 credits, 3 contact hours.
Prerequisites: NJIT: EE 657, R755 687; or equivalent. Intended for doctoral students in applied physics, electrical engineering, and materials science. (Rutgers = R755 789)Silicon and GaAS technologies: crystal growth methods, epitaxy, oxidation, lithography, dry and wet etching techniques, polysilicon, diffusion, ion implantation, metallization (including silicidation), process integration, analytical characterization techniques, assembly and packaging, and yield and reliability.

PHYS 790A. Doct Dissertation & Res. 1 credit, 1 contact hour.
Co-requisite: PHYS 791. Approval of the dissertation advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in applied physics. For PhD students who have successfully defended their dissertation proposal. The student must register in PHYS 790A every semester until successful dissertation defense. A written dissertation must be defended and approved by a committee of at least five members. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint PhD programs with other universities).

PHYS 791. Doctoral Seminar. 0 credits, 0 contact hours.

PHYS 792. Pre-Doctoral Research. 3 credits, 3 contact hours.
Co-requisite: PHYS 791. Approval of the dissertation advisor is required for registration. Preliminary experimental and/or theoretical investigation of a relevant topic in applied physics. For students who have passed the qualifying examination but have not defended the dissertation proposal. Permission is needed of the academic advisor as well for students who have completed the required coursework but have not passed the qualifying examination.

Rutgers-Newark Courses

R750 501. Quantum Mechanics. 3 credits, 3 contact hours.

R750 504. Elect & Magnetism II. 3 credits, 3 contact hours.

R750 509. Physics Appli Cmptrs. 3 credits, 3 contact hours.

R750 537. Recent Intl. Relations. 3 credits, 0 contact hours.

R750 543. Galaxies And Milky Ways. 3 credits, 3 contact hours.

R750 601. Solid State Physics I. 3 credits, 0 contact hours.

R750 602. Solid State Physics II. 3 credits, 3 contact hours.

R750 617. Genl Theo Relativity. 3 credits, 0 contact hours.

R750 620. Many Body Physics. 3 credits, 3 contact hours.

R750 621. Adv Many Body. 3 credits, 3 contact hours.

R750 681. Adv Top Sol State. 3 credits, 3 contact hours.

R750 771. Quantum Electronics. 3 credits, 3 contact hours.

R755 532. Quantum Mechanics. 3 credits, 3 contact hours.

R755 611. Special Topics in PHYS. 3 credits, 3 contact hours.

R755 701. Dissertation Research. 3 credits, 0 contact hours.

R755 702. Diss Research. 3 credits, 0 contact hours.

R755 710. ST:. 3 credits, 3 contact hours.

R755 771. Quantum Electronics. 3 credits, 0 contact hours.

R755 772. Plasma Physics. 3 credits, 0 contact hours.

R755 774. Intro To Spectro. 3 credits, 0 contact hours.

R755 780. Adv Quantum Mech. 3 credits, 3 contact hours.

R755 791. Doctoral Seminar. 0 credits, 0 contact hours.

R755 866. Grad Assistant. 6 credits, 3 contact hours.