

# Physics

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With a primary focus on applied physics, the department offers research-intensive programs at the undergraduate and graduate levels to prepare students for professional careers and to foster the scientific literacy that informed citizens need in the 21st century. Research areas that include solar physics, photonics, imaging and optical science, biophysics, material science, and microelectronics. In solar physics, NJIT's Big Bear Observatory in California is the most powerful ground-based optical telescope dedicated to the study of the Sun and the terrestrial impact of phenomena such as solar flares. Members of the Physics Department (<http://physics.njit.edu>) are also at the leading-edge of solar radio astronomy, at the Owens Valley Expanded Solar Array in California.

## 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 - B.S. (<http://catalog.njit.edu/undergraduate/science-liberal-arts/physics/applied-bs>)

- Biophysics - B.S. (<http://catalog.njit.edu/undergraduate/science-liberal-arts/physics/biophysics-bs>)

## Accelerated Programs (<http://catalog.njit.edu/undergraduate/academic-policies-procedures/special-degree-options>)

- Applied Physics - B.S./M.D. (<http://catalog.njit.edu/undergraduate/science-liberal-arts/physics/bs-md>)

## Double Majors (<http://catalog.njit.edu/undergraduate/academic-policies-procedures/special-degree-options>)

- Applied Mathematics and Applied Physics - B.S. (<http://catalog.njit.edu/undergraduate/science-liberal-arts/mathematical-sciences/applied-mathematics-applied-physics-bs>)
- Computer Science and Applied Physics - B.S. (<http://catalog.njit.edu/undergraduate/computing-sciences/computer-science/cs-applied-physics-bs>)

## Physics Courses

### **PHYS 102. General Physics. 3 credits, 3 contact hours (3;0;0).**

Prerequisite: None. Intended for students in architecture, computer science (B.A. only), STS and other disciplines requiring laboratory science electives. Elementary statics and dynamics. Subjects discussed are kinematics, Newton's laws of motion, energy, momentum, conservation principles, and mechanical properties of matter. Lab must be taken concurrently.

### **PHYS 102A. General Physics Laboratory. 1 credit, 2 contact hours (0;2;0).**

Prerequisite: None. This course is the laboratory component of PHYS 102 and must be taken concurrently.

### **PHYS 103. General Physics. 3 credits, 3 contact hours (3;0;0).**

Prerequisite: PHYS 102 with grade of C or better. A continuation of PHYS 102 for students in architecture, computer science (B.A. only), STS and other disciplines requiring laboratory science electives. Topics discussed are heat, thermodynamics, sound, wave motion, illumination, geometric and physical optics, and color. Lab must be taken concurrently.

### **PHYS 103A. General Physics Laboratory. 1 credit, 2 contact hours (0;2;0).**

Prerequisite: PHYS 102 with grade of C or better. This course is the laboratory component of PHYS 103 and must be taken concurrently.

### **PHYS 111. Physics I. 3 credits, 3 contact hours (3;0;0).**

Prerequisite: MATH 131; Corequisite: MATH 111 or MATH 132. Elementary mechanics with an emphasis on the fundamental concepts and laws of mechanics, especially the conservation laws. Topics are scalar and vector quantities of mechanics; rectilinear and circular motion; equilibrium and Newton's laws of motion; work, energy, momentum; the conservation laws. Lab must be taken concurrently. See PHYS 111A.

### **PHYS 111A. Physics I Laboratory. 1 credit, 2 contact hours (0;2;0).**

Corequisite: MATH 111. Laboratory component of PHYS 111. Lab must be taken concurrently with PHYS 111.

### **PHYS 114. Introduction to Data Reduction with Applications. 3 credits, 3 contact hours (3;0;0).**

Prerequisite: MATH 131; Corequisite: MATH 111 or MATH 132. Physics majors only. An introduction to both the theory and application of error analysis and data reduction methodology. Topics include the binomial distribution and its simplification to Gaussian and Poisson probability distribution functions, estimation of moments, and propagation of uncertainty. Forward modeling, including least-squares fitting of linear and polynomial functions are discussed. The course enables students to apply the concepts of the data reduction and error analysis using data analysis software to real data sets found in the physical sciences.

### **PHYS 121. Physics II. 3 credits, 3 contact hours (3;0;0).**

Prerequisites: PHYS 111 with a grade of C or better. MATH 111 or 132. Co-requisite: MATH 112 or MATH 133. This course deals with an introduction to electricity and magnetism. Topics include simple dc circuits, the electric field, the magnetic field, electric potential, capacitance relationships between electric and magnetic fields, inductance, and simple ac circuits. Lab must be taken concurrently. See PHYS 121A.

### **PHYS 121A. Physics II Laboratory. 1 credit, 2 contact hours (0;2;0).**

Prerequisites: PHYS 111 and MATH 111 all with grade of C or better. Corequisite: MATH 112.

### **PHYS 202. Introductory Astronomy and Cosmology. 3 credits, 3 contact hours (3;0;0).**

Prerequisite: None. A non-mathematical presentation of contemporary views of the origin, evolution, and structure of the solar system, stars, galaxies, and the universe. Special topics include neutron stars, black holes, gravitationally strange objects, and the "big bang".

### **PHYS 202A. Astronomy and Cosmology Laboratory. 1 credit, 2 contact hours (0;2;0).**

Corequisite: PHYS 202. Includes demonstration of physical principles applicable to astronomy. Use of telescope for lunar, solar and planetary observations.

### **PHYS 203. The Earth in Space. 3 credits, 3 contact hours (3;0;0).**

Prerequisite: None. Introduces fundamental phenomena, such as plate tectonics, erosion, volcanism, and glaciation. Studies the interaction between the Earth's four major reservoirs?atmosphere, hydrosphere, biosphere and solid earth; investigates the dependence of the Earth on the Sun; the effect of the Moon on the Earth. Extends knowledge gained from studying the Earth to other planets in this solar system.

### **PHYS 203A. The Earth in Space Laboratory. 1 credit, 2 contact hours (0;2;0).**

Corequisite: PHYS 203. Optional laboratory course associated with PHYS 203.

**PHYS 204. Biophysics of Life. 3 credits, 3 contact hours (3;0;0).**

A non-mathematical view of how living entities work in terms of the basic concepts of physics. The course will discuss how these concepts underline topics ranging from birth to death, from touch to pleasure, from vision to beauty, and from a thought to a heartbeat.

**PHYS 231A. Physics III Laboratory. 1 credit, 2 contact hours (0;2;0).**

Prerequisite: PHYS 121 and MATH 112, all with grade of C or better.

**PHYS 231H. Physics III Honors. 4 credits, 4 contact hours (4;0;0).**

Prerequisite: PHYS 121 or PHYS 121H and MATH 112 or MATH 112H, all with grade of C or better. Third semester of a three-semester program in Honors Physics. Physical optics is treated in greater detail. Modern physics includes a greater number of topics, with special emphasis on the wave-particle duality in nature. Lab must be taken concurrently. See PHYS 231A.

**PHYS 234. Physics III. 3 credits, 3 contact hours (3;0;0).**

Prerequisite: MATH 112. Elements of simple harmonic motion, wave motion, geometric and physical optics are considered. The wave and particle duality of nature is emphasized and made plausible by an examination of the important experiments and theories which lead to the modern concepts of matter and radiation. The conservation laws are broadened to include the equivalence of mass and energy.

**PHYS 310. Introduction to Atomic and Nuclear Physics. 3 credits, 3 contact hours (3;0;0).**

Prerequisites: PHYS 234; MATH 222, all with grade of C or better. Selected topics in atomic physics including the Pauli Exclusion Principle and the Atomic Shell Model. In nuclear physics, the two-body problem, nuclear models, alpha, beta, and gamma radiation, accelerators, and nuclear detectors are studied. R750 403 may be substituted for this course.

**PHYS 311. Co-op Work Experience I. 3 credits, 3 contact hours (0;0;3).**

Prerequisite: Acceptance into the co-op program. Students gain major-related experience and reinforcement of the academic program. Work assignments are facilitated and approved by the Office of Cooperative Education and Internships. Participation in seminars and a final report/project is mandatory. Note: Normal grading applies to this COOP Experience.

**PHYS 320. Astronomy and Astrophysics I. 3 credits, 3 contact hours (3;0;0).**

Prerequisites: PHYS 121, with grade of C or better. A quantitative introduction to the astronomy of the sun, earth, and solar system, with an emphasis on the physical principles involved. Includes celestial mechanics, planetary atmospheres and the physics of comets, asteroids and meteorites.

**PHYS 321. Astronomy and Astrophysics II. 3 credits, 3 contact hours (3;0;0).**

Prerequisite: PHYS 320, with grade of C or better. A quantitative introduction to the astronomy of the stars, the galaxy, and cosmology, with an emphasis on the physical principles involved. Includes stellar interiors, stellar evolution, galactic dynamics, large-scale structure and early history of the universe.

**PHYS 322. Observational Astronomy. 3 credits, 3 contact hours (3;0;0).**

Prerequisite: PHYS 320, with grade of C or better. Most class time is spent in an observatory performing observations of celestial objects such as the Sun, Moon, planets, stars, stellar clusters, and galaxies. Experimental projects include charting the skies, astrophotography (film and CCD), measuring masses of planets, rotational period of the Sun, topography of the Moon, H-R diagrams of stellar clusters, etc.

**PHYS 335. Introductory Thermodynamics. 3 credits, 3 contact hours (3;0;0).**

Prerequisites: PHYS 234 or PHYS 231 and MATH 211 or MATH 213, all with grade of C or better. Corequisites: MATH 222, MATH 238 or MATH 335. Introductory thermodynamics, kinetic theory, statistical physics. Topics include equations of state, the three laws of thermodynamics, reversible and irreversible processes. R750 315 may be substituted for this course.

**PHYS 350. Biophysics I. 3 credits, 3 contact hours (3;0;0).**

Prerequisite: PHYS 121 with a grade of C or better. This course presents an introduction to general biophysics and a preparation for medical school and biotechnology careers. It features molecules, viruses and cells racing to form enormous electric fields, succumbing to diseases and creating life. It explains how key medical devices preserve life. It assesses students' progress using questions just like those on the medical school entrance exams and seeks an understanding of a few, simple principles of life science.

**PHYS 390. Selected Topics of Current Interest in Physics. 1 credit, 1 contact hour (1;0;0).**

Prerequisite: PHYS 234 with grade of C or better. Seminar covering topics that are currently in the forefront of physics. The lecture series offers exposure to such topics as nuclear physics, solid state physics, plasma physics, the special and general theories of relativity, and the history and philosophy of science.

**PHYS 411. Co-op Work Experience II. 3 credits, 3 contact hours (0;0;3).**

Prerequisites: PHYS 311, with grade of C or better, and acceptance into the co-op program. Provides for co-op work assignments which must be approved by the Office of Cooperative Education and Internships. Participation in seminars and a final report/project are mandatory. Note: Normal grading applies to this COOP Experience.

**PHYS 418. Fundamentals of Optical Imaging. 3 credits, 4 contact hours (2;2;0).**

Prerequisites: PHYS 234 or PHYS 231, with grade of C or better. This is a course with both lectures and experiments and the emphasis is on the hands-on experiences. Upon completion of the course, students should not only grasp the basic concepts involved in imaging science, but also be able to work on simple real world imaging systems. The main content of the lecture part of this course can be summarized as the following: Optical sources, detectors and their working mechanism; Image formation and transmission; Optical imaging system and their characteristics; Imaging processing and algorithms. This course is developed in close collaboration with Edmund Optics Inc.

**PHYS 420. Special Relativity. 3 credits, 3 contact hours (3;0;0).**

Prerequisites: PHYS 234 and MATH 222, all with grade of C or better. An introduction to Einstein's Special Theory of Relativity at the advanced undergraduate level. Topics include invariance of the speed of light, relativity of time and space, the Lorentz transformations, space-time diagrams, the twin paradox and time travel, relativistic mechanics, rotating reference frames, laser gyroscopes, superluminal motion, phase and group velocities, and applications in high-energy physics, relativistic engineering, nuclear physics, astrophysics, and cosmology.

**PHYS 421. General Relativity. 3 credits, 3 contact hours (3;0;0).**

Prerequisites: PHYS 234 and MATH 222, all with grade of C or better. An introduction to Einstein's General Theory of Relativity at the advanced undergraduate level. Topics include review of Newton's Theory of Gravitation, review of Einstein's Special Theory of Relativity, tensor calculus on both flat and curved manifolds, the covariant derivative, curvature, Einstein's Gravitational Field Equations, the weak-field limit, gravitational radiation, the black hole solution, Hawking radiation, the No-Hair Theorem, cosmology, and a history of the Universe.

**PHYS 430. Classical Mechanics I. 3 credits, 3 contact hours (3;0;0).**

Prerequisites: PHYS 234 and MATH 222 and MATH 328 or MATH 335, all with grade of C or better. Newtonian mechanics of particles and systems. Lagrange's and Hamilton's approaches. Continuous systems. R750 361 may be substituted for this course.

**PHYS 431. Classical Mechanics II. 3 credits, 3 contact hours (3;0;0).**

Prerequisites: PHYS 430, with grade of C or better. Theory of small oscillations and mechanical waves. Rigid bodies. Topics include stability, linearization methods, forced vibrators and perturbation theory, fluids and mechanics of continuous media. 21&62 750 362 may be substituted for this course.

**PHYS 432. Electromagnetism I. 3 credits, 3 contact hours (3;0;0).**

Prerequisite: Phys 234 or Phys 234H or Phys 231H and Math 222 or Math 222H and Math 328 or Math 335, all with grade of C or better. Electrostatics and magnetostatics, Maxwell's equations with applications, and electrodynamics.

**PHYS 433. Electromagnetism II. 3 credits, 3 contact hours (3;0;0).**

Prerequisite: PHYS 432, with grade of C or better. Maxwell's equations with applications and electrodynamics.

**PHYS 441. Modern Physics. 3 credits, 3 contact hours (3;0;0).**

Prerequisites: PHYS 234 or PHYS 231 and MATH 222, all with grade of C or better. Topics include wave-particle duality, wave mechanics, two-state quantum systems, the motion of an electron in a periodic lattice, band theory of solids, electrical, thermal and magnetic properties of solids, and plasmas and super fluid systems. R750 316 may be substituted for this course.

**PHYS 442. Introduction to Quantum Mechanics. 3 credits, 3 contact hours (3;0;0).**

Prerequisite: PHYS 430, with grade of C or better. Wave-particle duality, the Schrodinger and Heisenberg formulations of quantum mechanics. The hydrogen atom, perturbation theory, and concepts of degeneracy, composite states and general properties of eigenfunctions. R750 404 may be substituted for this course.

**PHYS 443. Modern Optics. 3 credits, 3 contact hours (3;0;0).**

Prerequisites: PHYS 234 or PHYS 231 and MATH 222, all with a grade of C or better. Electromagnetic theory of light, interference, diffraction, polarization, absorption, double refraction, scattering, dispersion, aberration, and an introduction to quantum optics. Other topics include holography, lasers, information retrieval, spatial filtering, and character recognition.

**PHYS 444. Fluid and Plasma Dynamics. 3 credits, 3 contact hours (3;0;0).**

Prerequisites: PHYS 234 or PHYS 231 and MATH 222, all with grade of C or better. Introduces the basics of plasma physics. Covers the following plasma parameters, single particle motions, plasma as fluid, waves, diffusion and resistivity, equilibrium and instability, kinetic theory, nonlinear effects. Applications in three areas: controlled fusion, astrophysics, and interaction between light and plasma.

**PHYS 446. Solid State Physics. 3 credits, 3 contact hours (3;0;0).**

Prerequisite: MATH 222, with grade of C or better. Corequisite: PHYS 442. An introduction to modern concepts of the solid state. Topics include crystal structure and diffraction, crystal binding and elastic properties, thermal properties, dielectric phenomena, band theory of solids and Fermi surfaces, electrical conductors, semiconductors, magnetism, and super-conductivity. R750 406 may be substituted for this course.

**PHYS 450. Advanced Physics Laboratory. 3 credits, 5 contact hours (1;4;0).**

Prerequisites: PHYS 335, PHYS 430, PHYS 432, all with grade of C or better. Introduction to electrical measurements; instrumentation; theoretical and applied electronics, solid state electronic devices, digital circuitry; computer design; experiments in modern physics.

**PHYS 451. Biophysics II. 3 credits, 3 contact hours (3;0;0).**

Prerequisites: PHYS 121 with a grade of C or better. An introduction to electrical aspects of biophysics and a preparation for medical school and biotechnology careers. Covering how medical devices work and using active learning with reports on new research.

**PHYS 452. Atomic and Nuclear Physics. 3 credits, 3 contact hours (3;0;0).**

Prerequisites: PHYS 234 or PHYS 231 and MATH 222, all with grade of C or better. Topics include atomic spectra, atomic structure, and nuclear physics.

**PHYS 456. Introduction to Solid State Physics. 3 credits, 3 contact hours (3;0;0).**

Prerequisites: PHYS 234 or PHYS 231 and MATH 222, all with grade of C or better. Treats the same topics as PHYS 446 while introducing the necessary modern physics. Designed for students choosing a minor in applied physics. Students majoring in applied physics are ineligible.

**PHYS 461. Mathematical Methods of Theoretical Physics. 3 credits, 3 contact hours (3;0;0).**

Prerequisites: PHYS 430, PHYS 432, PHYS 433, all with grade of C or better. Topics include vector and tensor analysis, matrix methods, complex variables, Sturm-Liouville theory, special functions, Fourier series and integrals, integral equations, and numerical solutions of differential equations.

**PHYS 480. Topics in Applied Physics. 3 credits, 3 contact hours (3;0;0).**

Prerequisite: Permission of instructor. Current topics and interests in applied physics and physics. Emphasis is on research and scientific development in microelectronics, optoelectronics, optical physics, materials science, surface science, solar physics, and modern physics.

**PHYS 481. Applied Solid State Physics: Microelectronics I. 3 credits, 3 contact hours (3;0;0).**

Prerequisite: PHYS 446, with grade of C or better. Topics include physics of bipolar and field effect devices, Phonon and optical spectra, unipolar devices, and thermal and high field properties of semiconductor devices.

**PHYS 482. Applied Solid State Physics: Microelectronics II. 3 credits, 3 contact hours (3;0;0).**

Prerequisite: PHYS 446, with grade of C or better. Topics include large-scale integrated circuits, device characteristics, charge-coupled devices, LED and semiconductor lasers, photodetectors, and electrical and optical properties of materials.

**PHYS 483. Applied Solid State Physics. 3 credits, 6 contact hours (0;6;0).**

Prerequisite: PHYS 446, with grade of C or better. Introduction to digital concepts; binary circuits and microprocessor architecture. Applications of discrete solid-state devices and integrated circuits are explored both in theory and practice. The laboratory also serves as an introduction to hardware and software components of a typical microcomputer.

**PHYS 485. Computer Modeling of Applied Physics Problems. 3 credits, 3 contact hours (3;0;0).**

Prerequisites: PHYS 234 or PHYS 231 and MATH 222, all with grade of C or better. General computer programming modeling methods and techniques. Numerical solutions to integro-differential equations. Eigenvalues problems. Application of computer-aided-design and other packages. R750 461 may be substituted for this course.

**PHYS 490. Independent Study. 3 credits, 3 contact hours (0;0;3).**

Prerequisite: Departmental approval. Undertake individual research or a project under the supervision of a member of the physics department. 21&62 750 485, 486 may be substituted for this course.

PHYS 491. Independent Study II. 3 credits, 3 contact hours (0;0;3).

## Rutgers-Newark Courses

R750 109. Astronomy & Cosmology. 3 credits, 3 contact hours (3;0;0).

R750 110. Astronomy & Cosmology. 3 credits, 3 contact hours (3;0;0).

R750 131. Elements Of Physics. 3 credits, 0 contact hours (0;0;0).

R750 133. Elements Of Physics Lab. 1 credit, 1 contact hour (0;1;0).

R750 202. Physics As Librl Art. 3 credits, 0 contact hours (0;0;0).

R750 203. General Physics I. 4 credits, 3 contact hours (3;0;0).

R750 204. General Physics II. 4 credits, 4 contact hours (4;0;0).

R750 205. Intro Physics Lab. 1 credit, 1 contact hour (0;1;0).

R750 206. Intro To Physics Lab. 1 credit, 1 contact hour (0;1;0).

R750 213. Univ Physics. 4 credits, 4 contact hours (4;0;0).

R750 214. Elements Of Physics. 4 credits, 4 contact hours (4;0;0).

R750 222. Dynamics. 3 credits, 3 contact hours (3;0;0).

R750 307. Computer Electronics. 4 credits, 4 contact hours (4;0;0).

R750 308. Computer Electronics. 3 credits, 0 contact hours (0;0;0).

R750 315. Intro Thermodynamics. 3 credits, 3 contact hours (3;0;0).

R750 316. Modern Physics. 3 credits, 3 contact hours (3;0;0).

R750 333. App Math To Physics. 3 credits, 3 contact hours (3;0;0).

R750 361. Mechanics I. 3 credits, 3 contact hours (3;0;0).

R750 362. Mechanics. 3 credits, 3 contact hours (3;0;0).

R750 364. Applied Math To Physics. 3 credits, 3 contact hours (3;0;0).

R750 385. Elec-Magn Fields & Waves. 3 credits, 3 contact hours (3;0;0).

R750 386. Elec-Magn Flds & Waves. 3 credits, 3 contact hours (3;0;0).

R750 396. Trumpet. 1 credit, 0 contact hours (0;0;0).

R750 403. Intro Atom & Nucl Phys. 3 credits, 3 contact hours (3;0;0).

R750 404. Quantum Mechanics. 3 credits, 3 contact hours (3;0;0).

R750 406. Solid State Physics. 3 credits, 3 contact hours (3;0;0).

R750 407. Advancd Phys Lab I. 1 credit, 0 contact hours (0;0;0).

R750 408. Adv Physics Lab II. 1 credit, 1 contact hour (0;1;0).

R750 410. Physical Electronics. 2 credits, 2 contact hours (2;0;0).

R750 411. Physical Optics. 3 credits, 3 contact hours (3;0;0).

R750 446. Solid State Physics. 3 credits, 0 contact hours (0;0;0).

R750 461. Computation Physics. 3 credits, 3 contact hours (3;0;0).

R750 462. Adv Math Meth In Phy. 0 credits, 0 contact hours (0;0;0).

R750 485. Individual Research. 1-3 credits, 3 contact hours (3;0;0).

R750 486. Individual Research. 3 credits, 0 contact hours (0;0;0).

R750 492. Physics Seminar. 1 credit, 1 contact hour (1;0;0).

R750 493. Readings In Physics. 3 credits, 3 contact hours (3;0;0).

R750 494. Reading In Physics. 3 credits, 3 contact hours (3;0;0).