PHY 099/Orientation to Physics **0 course unit**
(fall, every year)
Required as an entry course of all first-year and transfer students enrolled in majors offered by the Department of Physics. Topics covered include degree requirements, general information about the college and services offered, career opportunities in physics, academic standards and integrity, study habits, time management, and resume development. General and personal advisement relative to pursuit of the major and the degree is also included.

PHY 103/Physical, Earth, and Space Sciences **1 course unit**
(with laboratory)
(every semester)
Restricted to students in Elementary Education, Early Childhood Education, Education of the Deaf and Hard of Hearing, and Special Education.
This course introduces various topics from physical, earth, and/or space sciences, such as motion, Newton's laws, energy, momentum, thermal energy, fluids, light, electromagnetic forces and fields, the Earth, the Solar System and the universe. Algebra-based equations, graphs, and scientific notations are used. Concepts are reinforced through laboratory experiments and problem-solving. This course is designed for elementary-level education majors to help them meet New Jersey state standards.

PHY 120/Introduction to Geology **1 course unit**
(with laboratory)
(every semester)
Geological concepts, principles, and processes as they relate to the relationship between people and their environment are emphasized. Topics include: minerals and rocks, components of the hydrologic cycle, dynamic earth processes, and regional studies.

PHY 121/Principles of Physics **1 course unit**
(with laboratory)
(fall, every year)
Not for science or mathematics majors
Centered around the basic laws of physics, emphasis is on a conceptual understanding of the natural world regarding concepts which comprise it and their connections and relationships to each other. Topics include force, motion, momentum, energy and gravitation. Laboratory emphasis is given through hands-on activities.

PHY 144/Physics of Everyday Life **1 course unit**
(with laboratory)
(every year)
Not for science or mathematics majors
Physics is around us every day. What makes lightning? How do airplanes fly? Why do we see the world in color? Why do icebergs float? Why is the sky blue? What if we shot an arrow on the Moon? Should you go bungee jumping? Basic laws of physics that underlie these and other phenomena will be explored. Algebra-based formulas will be used.

PHY 161/Introduction to Astronomy **1 course unit**
(with laboratory)
(every semester)
A study of the knowledge gained in our investigation of the universe from an historical perspective. Topics included are the Earth and its motions; time and the calendar, the seasons; the properties, origin, and evolution of the solar system, and stars and stellar systems, including galaxies; and cosmology. Laboratory sessions will involve an investigation of observable

celestial phenomena, including celestial coordinates, the diurnal motions of the stars, the orbital motions of the planets, the phases of the Moon, and eclipses, through the use of interactive computer software, and the TCNJ planetarium and observatory facilities. Some nighttime observing is required.

PHY 171/Introduction to Meteorology **1 course unit**
(with laboratory)
(spring, every year)
Basic weather processes and forecasting are emphasized. Topics include: the Earth-Sun System, heat balance, moisture and precipitation, air masses and fronts, storm systems, ocean circulation, climate, atmospheric optics, air pollution and satellite imagery.

PHY 201/General Physics I **1 course unit**
(with laboratory)
(every semester)
Pre- or Corequisite: MAT 125 or MAT 127
Calculus-based introductory physics, first course of a two semester sequence. Topics covered include motion, Newton's Laws, conservation principles, rotational motion and oscillatory behavior. Problem solving is an integral part of the course. Conceptual understanding is reinforced using interactive computer-based techniques, demonstrations, and laboratory experiences.

PHY 202/General Physics II **1 course unit**
(with laboratory)
(every semester)
Prerequisites: PHY 201 and MAT 127
Usual Pre- or Corequisite: MAT 128
Second part of two semester calculus-based introductory course. Topics include: electricity and magnetism, optics, and topics in modern physics. Problem solving is an integral part of the course. Conceptual understanding is reinforced using interactive computer-based techniques, demonstrations, and laboratory experiences.

PHY 203/Physics I for Physicists **1 course unit**
(with laboratory)
(fall semester)
Pre- or Co-requisite: MAT 127
This is an accelerated calculus-based introductory physics course, the first of a two-semester sequence for Physics majors and Honors students. Topics covered include linear and circular motion, Newton's Laws, linear and angular momentum, conservation of energy, gravitation, oscillations, and fluids. Conceptual understanding is reinforced using extended laboratory experiments, demonstrations, and homework assignments.

PHY 204/Physics II for Physicists **1 course unit**
(with laboratory)
(spring semester)
Pre-requisites: MAT 127 and PHY 203 or PHY 201
Pre- or Co-requisite: MAT 128
Second part of an accelerated two semester calculus-based introductory course in electricity and magnetism, optics, and topics in thermal physics designed for Physics majors and Honors students. The important laws of physics in these areas and problem solving are emphasized. Problem solving is an integral part of the course. Conceptual understanding is reinforced using interactive computer-based techniques, demonstrations, and extended laboratory experiences.

PHY 220/Advanced Geology **1 course unit**
(with laboratory)
(spring, odd-numbered years)
Prerequisites: PHY 120 (recommended) or PHY 201 or permission of instructor and WRI 102 or waiver
The goal of this course is to present a modern, inquiry-based introduction to plate tectonics, earthquakes, and volcanoes. Topics include seismic wave interpretation, fault mechanics, earthquake prediction, volcanic hazards, volcanism and climate change, and more. This is a mid-level writing intensive course and students will write two formal laboratory reports and a term paper from a topic of their choosing related to the course material.

PHY 261/Advanced General Astronomy **1 course unit**
(fall, odd-numbered years)
Prerequisites: MAT 128 or permission of instructor and WRI 102 or waiver
This course is a study of the knowledge gained from the investigation of the stellar universe, including the Sun and its satellites. Topics include the properties, structure, and evolution of stars, star clusters, galaxies, and cosmology. An emphasis will be placed on the methodology employed by astronomers and astrophysicists to investigate the stellar world. The methods used for the analysis of observational data are facilitated by the use of interactive computer software in the astronomy lab. The course involves some simple programming. Use will also be made of the planetarium and facilities of the TCNJ observatories. This is a mid-level writing intensive course.

PHY 290/Learning Assistant Program: Laboratory **0.5 course units**
(every semester)
Pre-requisite: PHY 202 and permission of instructor and Chair
Learning assistants (LAs) develop competency through the facilitation of physics laboratories, demonstrations, peer-to-peer learning, and promotion of other learning-enhancing behaviors by Physics 201 or 202 lab students. The LAs will be tasked with promoting discussion and creative problem solving during all laboratory sessions of a single lab section. LAs will gain detailed understanding of the technical details associated with intro physics lab exercises as well as critical early teaching and mentoring experience. Specific duties for a LA are detailed in a contract that is developed and signed by both the student and instructor.

PHY 291/Learning Assistant Program: Lecture **0.5 course units**
(every semester)
Pre-requisite: PHY 202 and permission of instructor and Chair
Learning assistants (LAs) develop competency through the facilitation of physics lectures, demonstrations, peer-to-peer learning, and promotion of other learning-enhancing behaviors by PHY 201 and 202 lecture students. LAs facilitate class discussion by asking clarifying questions, suggesting ideas students might want to consider, providing new perspectives on an issue, or summarizing the discussion. LAs facilitate small groups by framing the work of the group in ways that support the learning goals, by bringing reserved students into the small group conversation, and by encouraging students to come to class prepared. Specific duties for the LAs are detailed in a contract that is developed and signed by both the student and instructor.

PHY 299/Research Fundamentals Seminar **0.25 course unit**
(*Offered every semester.* This course is a graduation requirement to be taken during the sophomore or junior year.)
Pre-requisite: PHY 099 or department permission
This seminar course is designed to contextualize current research topics in physics and provide exposure to the fundamental techniques required to pursue scholarly research in the physical sciences. Students will attend departmental and school colloquia and examine primary academic

literature to synthesize speakers' scholarly records with the attended talks. Students will also design and propose a small-scale research project that could lead to an independent research experience in subsequent semesters.

PHY 306/Mathematical Physics **1 course unit**
(fall, every year)
Prerequisites: PHY 202 and MAT 128
A study of the mathematical methods used by experimental and theoretical physicists to solve a variety of physical problems. Topics include complex numbers, partial derivatives, multiple integrals, curvilinear coordinates, matrix algebra, vector and tensor calculus, Fourier analysis, ordinary and partial differential equations, boundary value problems, special functions and advanced numerical techniques. Mathematica and/or Fortran will be used for both algebraic and numerical computations.

PHY 311/Analog and Digital Electronics **1 course unit**
(with laboratory)
(fall, even-numbered years)
Prerequisite: PHY 202
Fundamentals of analog and digital circuits. Topics in analog electronics include circuit analysis, alternating current circuits, transient signals, frequency filters, diodes, transistors, and op-amp circuits. Topics in digital electronics include logical networks, flip-flops, analog-to-digital-to-analog converters, microcomputers, and transducer applications. Laboratory activities are hands-on with intensive use of oscilloscopes, frequency generators, analog components, transducers and robots. A robotics competition is a capstone experience for this course.

PHY 316/Biomedical Physics **1 course unit**
(spring, even-numbered years)
Prerequisite: PHY 202
A study of physics that has medical and biological applications. Intended for physics and other majors who are adept at problem solving and are often interested not only in careers in physics, but also in medicine, biology, biophysics, or medical physics. Topics include electrical properties of nerve and muscle cells, conduction system of the heart, theory of electrocardiography, scattering, absorption, and emission of radiation, thermodynamics of living systems, medical use of x-rays, computed tomography (CT), PET scanners, nuclear physics and nuclear medicine, and magnetic resonant imaging (MRI).

PHY 321/Modern Physics **1 course unit**
(with laboratory)
(fall, every year)
Prerequisite: PHY 202, MAT 128
Study of modern physics concepts pertaining to the microscopic universe, thereby giving the student a better understanding of the macroscopic universe. Fundamental concepts of modern physics are covered, including topics in the special theory of relativity, wave-particle duality, quantization of energy, Schrodinger equation, potential wells, and atomic physics. The experimental basis for modern physics is also discussed.

PHY 336/Introduction to Biophysics **1 course unit**
(spring, odd-numbered years)
Prerequisite: PHY 202 or permission of instructor
Introduction to physical principles underlying biology and biological phenomena. Topics include free energy, entropy and thermodynamics; diffusion, molecular motion and self-assembly; excitable membranes, neurons, and neurocomputation. In addition, a survey of quantitative tools and modeling techniques will be given. Appropriate for juniors and seniors in physics, chemistry and biology who have completed calculus and introductory physics courses.

PHY 345/Physics of Clouds and Climate **1 course unit**
(spring, even-numbered years)
Prerequisite: PHY 202 or PHY 201and MAT 128 and WRI 102 or waiver
This is a course focused on the study of the physical components and processes of Earth's atmosphere, with special focus on the intertwined physics of clouds and climate change. The course takes an interactive approach to understanding clouds and radiation in the atmosphere, including collaborative problem solving, topical literature review and writing, tutorials on state-of-the art weather forecasting software, 3D visualizations, and several field exercises. The course satisfies the mid-level writing assignment.

PHY 356/Thermal Physics **1 course unit**
(spring, every year)
Prerequisites: PHY 202, and PHY 306 or MAT 229
A study of the interrelationships between temperature, thermal energy, work, and entropy and the interactions of physical systems. The main topics covered are thermodynamic coordinates, equations of state, the laws of thermodynamics, adiabatic processes, heat engines, kinetic theory and statistical thermodynamics.

PHY 361/Galactic and Extragalactic Astronomy **1 course unit**
(fall, even-numbered years)
Prerequisites: PHY 202 (or PHY 161 and permission of instructor) and WRI 102 or waiver.
Study of the composition, structure and kinematics of our home Galaxy, the Milky Way, and the corresponding properties of other galaxies. Interplay between stars and interstellar medium; spiral, elliptical and irregular galaxies; galaxy formation and evolution; active galactic nuclei; the cosmic distance ladder. This is a mid-level writing intensive course: students will write multiple drafts of review papers covering specific topics within this broad field.

PHY 370/Topics in Physics **1 course unit**
(occasionally)
Prerequisite: Department permission.
Topics such as plasma physics, or computational fluid dynamics will be covered.

PHY 371/Topics in Physics (Writing Intensive) **1 course unit**
(occasionally)
Pre-requisite: Department permission and WRI 102 or waiver
Topics such as plasma physics or computational fluid dynamics will be covered within the framework of a mid-level writing intensive experience.

PHY 390/Methods of Teaching Science **1 course unit**
(fall, every year)
Prerequisite: Department permission and WRI 102 or waiver
Research and presentations of topics relating to issues in modern science education with special emphasis on the first-year teacher. Topics include evolution of scientific concepts, presentations and evaluations of demonstrations, classroom management and techniques with an emphasis on preparation for Student Teaching.

PHY 391/Independent Study in Physics **variable course units**
(every semester)
Prerequisites: Junior/senior standing and permission of faculty mentor and department chair; available to students with sophomore standing with permission of instructor.
A student, in collaboration with a faculty member, will study an advanced topic in physics or a related field.

PHY 393/Independent Research I **variable course units**
(every semester)
Prerequisite: Junior/senior standing in Physics with a minimum 2.5 GPA and approval of supervising faculty member and department chair; available to students with sophomore standing with permission of instructor.
Independent study in a selected area of physics, geology, meteorology or astronomy through the use of scientific journals, source books and experimentation or computation. This course is normally appropriate for students of sophomore or junior standing, with a GPA of 2.5 or higher. A poster paper or oral presentation describing the research results are given to the department at the end of the semester.

PHY 399/Physics Research Internship **1 course unit**
(every fall; may be repeated once for credit)
Prerequisite: Department permission.
The course provides an opportunity for students to receive TCNJ credits for pertinent internships or research experiences at off-campus institutions through an extension of that work with a TCNJ Faculty Mentor (FM). To register, the student needs to obtain prior approval from the FM and Chair of the Physics Department. In the course, the student is expected to actively engage in literature search and to work closely with the FM to synthesize the work done during the internship, to produce and deliver an oral or poster presentation, and to write a high quality paper based on the research. This is a writing intensive course.

PHY 401/Classical Mechanics **1 course unit**
(spring, every year)
Prerequisites: PHY 306 or MAT 229 and PHY 321
Recommended Prerequisite: MAT 326
Newtonian mechanics is studied rigorously using advanced mathematical and numerical techniques . Topics treated include kinematics, dynamics, harmonic oscillations, central forces, many particle systems, rigid bodies, Lagrangeans, and Hamiltonians. Scientific programming is used extensively in problem solving.

PHY 411/Electromagnetic Waves and Optics **1 course unit**
(with laboratory)
(fall, odd-numbered years)
Prerequisites: PHY 306 or MAT 229
Properties of electromagnetic waves are studied, with a focus on visible light. Topics include wave motion, interaction of electromagnetic waves with matter, geometrical and physical optics, polarization, optical instruments, holography, laser physics, and quantum optics at an intermediate level. Laboratory work involves designing experiments to verify physical models and use of photonics research equipment. The course provides the foundation for imaging, laser physics and optical spectroscopy techniques.

PHY 413/General Relativity and Cosmology **1 course unit**
(fall, even-numbered years)
Prerequisites: PHY 306 or MAT 229 or permission of instructor
Modern formulation of Einstein's General Relativity. This course emphasizes field equations and the solutions applicable to astrophysical problems, including topics relating to black holes, gravitational lensing, and gravitational radiation. Additional topics include the dynamics of the universe--Standard Cosmology. The course provides a strong background suitable for higher studies in theoretical physics, astronomy, or mathematics.

PHY 421/Electromagnetic Theory I **1 course unit**
(fall, every year)
Prerequisites: PHY 306 or MAT 229
Recommended Pre/Co-requisite MAT 326
A study of the theory and laws of classical electromagnetism and development of the basic concepts and equations of electrostatics. Topics to be addressed are: applications of Coulomb's Law, nature of the electric field, applications of Gauss' Law, potential, theory, dielectric theory, conductors in electromagnetic fields, energy of the electromagnetic field, and special methods in electrostatics.

PHY 422/Electromagnetic Theory II **1 course unit**
(spring, even-numbered years)
Prerequisite: PHY 421
A continuation of PHY 421 dealing with electric currents and magnetic fields, Biot-Savart Law, Faraday Induction Law, magnetic potential, Maxwell's Equations, and electromagnetic waves.

PHY 426/Particle and Nuclear Physics **1 course unit**
(spring, even-numbered years)
Prerequisites: PHY 321, or permission of instructor
Fundamental concepts and applications of Particle and Nuclear Physics will be discussed such as the standard model, the shell model of nuclei, accelerators, radioactivity, nuclear medicine, nuclear reactors and nuclear waste. Seminars, problem solving and computer projects are integral parts of the course.

PHY 431/Quantum Mechanics **1 course unit**
(fall, every year)
Prerequisites: PHY 306 and PHY 321 or permission of instructor
Quantum mechanical properties of matter are studied using the Schrödinger and matrix approaches. Topics: mathematical tools and postulates of quantum mechanics, time evolution of the system's state, conservation laws, quantum mechanics in one and three dimensions, orbital and spin angular momenta, and approximation methods.

PHY 436/Condensed Matter **1 course unit**
(spring, odd-numbered years)
Prerequisites: PHY 306 or MAT 229 and PHY 321
Fundamental concepts of condensed matter and applications to problems in current theoretical and applied physics are presented. Topics covered include crystal structure, lattice vibrations, phonons, thermal properties of matter, free electron theory of metals, band theory, semiconductors, superconductors, optical properties of solids and magnetism. Problem solving and computer projects are integral parts of the course.

PHY 451/Advanced Experimental Physics **1 course unit**
(every spring)
Prerequisites: PHY 306, and PHY 321 and PHY 311 or PHY 411 or permission of instructor, and WRI 102 or waiver
This is a course in experimental physics at an intermediate to advanced undergraduate level. Experiments include specific charge of the electron, nuclear radioactivity, quantum nature of light, optical rotation in solids, measurement of the gravitational constant, phase-sensitive electronic detection, optical polarization and compensation, measurement of electron spin, and measurement of magnetic torque. Students will work in teams to complete approximately 5 experiments over the course of the semester. Some of the learning goals for the course are to become familiar with common experimental techniques, proper laboratory documentation, and error propagation and analysis. Students will perform background reading and pre-lab assignments and design and construct each experiment. In addition to daily writing in a laboratory notebook, students will also produce a final paper on one of their experiments; this

course is therefore an upper-level writing intensive course that can serve as a capstone course. Note that this course has an attendance requirement of 12 hours per week in the laboratory.

PHY 466/Astrophysics **1 course unit**
(spring, odd-numbered years)
Prerequisites: PHY 321 or permission of instructor
The study of the knowledge gained from the investigation of the stellar universe and the physics applied thereto. This includes atomic structure, radiative processes, spectroscopy, thermostatistics of excitation and ionization equilibria, photometry, radiation transport, absorption, and scattering theory. Also covered are the principles of stellar structure and evolution; the structure and evolution of star clusters, galaxies and cosmology. An emphasis will be placed on the methodology employed by astrophysicists to investigate the stellar world.

PHY 478/Special Topics in Condensed Matter **1 course unit**
(occasionally)
This course is an introduction to the optical properties of materials, with an emphasis on modern photonic materials and characterization techniques. These topics are at the core of many emerging technologies such as high-definition displays, fiber optic networks and advanced sensors. Topics covered include a review of ray and wave optics, polarization, interference and diffraction. This is followed by a discussion of the relevant classical, semi-classical and quantum interpretations of the interaction of matter with electromagnetic radiation. The basis physics of lasers, LED sources, solid-state detectors, and photon-counting devices will also be discussed, including an overview of photonics tools and techniques, such as laser beam characterization, nonlinear optical techniques, and optical microscopy. Although there is no formal lab for this course, students will have the opportunity to work on a team-based experimental project. Project topics will be discussed with, and approved by, the instructor.

PHY 490/Student Teaching: Physics **2 course units**
(every semester)
Prerequisites: PHY 390 and meeting all criteria for admission to student teaching, including completion of all required courses and Physics requirements.
Student teaching during one semester of the senior year with an approved teacher in a public school under supervision of the cooperating teacher and college supervisors.

PHY 493/Independent Research II **variable course units**
(every semester)
Prerequisites: Senior standing in physics and permission of faculty mentor and department chair
This writing-intensive, capstone experience will consist of the student, in collaboration with a faculty mentor, studying an advanced research topic. A scientific talk and written research-quality paper will be submitted to the department at the end of the semester.