Physics

Faculty: Ochoa, *Chair;* Becker, Dalafave, Gleeson, Kolp, Pfeiffer, Wickramasinghe

The objectives of the department are to develop the student's comprehension of the basic principles of physics, to instill a sense of inquiry in the student, to develop an appreciation of the role of physics in our attempt to understand the universe, and to develop an understanding of its power to deal with problems related to technology and the environment.

The physics major can, by proper choice of electives, prepare for graduate work in physics, astronomy, geophysics, environmental science, or professional schools such as medicine or law. The student may also choose to work in industry, public service, or teaching. The program for prospective teachers will prepare graduates to teach various courses ranging from high school physics to science in the junior high and middle schools, depending on the courses elected. Therefore, it is strongly recommended that the student elect those courses which will satisfy the demands of his or her chosen profession.

The computational physics track combines physics, computer science, and mathematics. A graduate of this program will have an understanding of physics and, in addition, will be able to apply computer knowledge to the solution of various technical problems.

Program Entrance, Retention, and Exit Standards

Every major program at the College has set standards for allowing students to remain in that program, to transfer within the College from one program to another, and to graduate from a program. The following are the standards for physics programs. Minimum grades are noted in parentheses.

- Retention in the program is based on the following performance standards in these "critical content courses": PHY 201 (C–), PHY 202 (C–), PHY 321 (C–).
- Transfer into the program from another program within the College is based upon the following performance standards in this "foundation course": PHY 201 (C–).
- Graduation requires a GPA of 2.0 in courses for the program and earning a minimum grade of C– in the following courses: PHY 201 (C–), PHY 202 (C–), PHY 321 (C–).

Study Abroad

One of the opportunities available to students pursuing a degree in physics is to study abroad for a semester. Any student interested in studying abroad should meet with his/her faculty advisor early in his/her college career to plan a curriculum so that the student may complete his/her studies in four years. He/she may also need to meet with the Office of Global Programs. The student must receive approval from the chairperson of the Physics Department in order for courses taken abroad to count toward requirements in the major.

Physics Major (PHYA)—Physics Liberal Arts Track

Physics Major Required Courses (14 course units)

PHY	099/Orientation to Physics	0 course unit
PHY	201, 202/General Physics I, II	2 course units

PHY	306/Mathematical Physics	1 course unit
PHY	311/Analog and Digital Electronics	1 course unit
PHY	321/Modern Physics	1 course unit
PHY	401/Classical Mechanics	1 course unit
PHY	411/Optics and Wave Motion	1 course unit
PHY	416/Thermodynamics	1 course unit
PHY	421, 422/Electromagnetic Theory I, II	2 course units
PHY	431/ Quantum Mechanics	1 course unit
PHY	451/Experimental and Analytical Physics	1 course unit
Two physics options (see below)		2 course units

Physics Major Option Courses (select two)

PHY	413/General Relativity and Cosmology	1 course unit
PHY	436/Condensed Matter	1 course unit
PHY	466/Astrophysics	1 course unit

Physics required correlates (six course units)

CHE	201, 202/General Chemistry I, II	2 course units
CSC	215/Computer Science I	1 course unit
MAT	127, 128/Calculus A, B	2 course units
MAT	326/Differential Equations	1 course unit

Suggested First–Year Sequence (PHYA)

Fall Semester

FSP	First Seminar	1 course unit
PHY	099/Orientation to Physics	0 course unit
PHY	201/General Physics I	1 course unit
MAT	127/Calculus A	1 course unit
Liberal Learning		1 course unit

Spring Semester

PHY	202/General Physics II	1 course unit
CSC	215/Computer Science I OR 220/Computational Problem Solving	1 course unit
MAT	128/Calculus B	1 course unit
WRI	102/Academic Writing* (if not exempted)	1 course unit

**It is recommended that students exempted from this course take another liberal learning course.*

Physics Major (PHYC)—Computational Physics Track

Physics Major Required Core Courses (five course units)

PHY	099/Orientation to Physics	0 course unit
PHY	201, 202/General Physics I, II	2 course units
PHY	306/Mathematical Physics	1 course unit
PHY	311/Analog and Digital Electronics	1 course unit
PHY	321/Modern Physics	1 course unit

Physics Options (select six course units)

PHY	316/Biomedical Physics	1 course unit

PHY	393/Independent Research I	1 course unit
PHY	401/Classical Mechanics	1 course unit
PHY	411/Optics and Wave Motion	1 course unit
PHY	413/General Relativity and Cosmology	1 course unit
PHY	416/Thermodynamics	1 course unit
PHY	421/Electromagnetic Theory I	1 course unit
PHY	422/Electromagnetic Theory II	1 course unit
PHY	426/Particle and Nuclear Physics	1 course unit
PHY	431/Quantum Mechanics	1 course unit
PHY	436/Condensed Matter	1 course unit
PHY	451/Experimental and Analytical Physics	1 course unit
PHY	493/Independent Research II	1 course unit
PHY	466/Astrophysics	1 course unit

Computation Core (six course units)

MAT	127, 128/Calculus A,B	2 course units
CSC	220/Computational Problem Solving	1 course unit
CSC	230/Computer Science II	1 course unit
CSC	310/Discrete Structures	1 course unit
CSC	340/Programming in the Large	1 course unit

Computation Options (three course units—by advisement)

CSC	325/Computer Architecture	1 course unit
CSC	350/Computer Graphics	1 course unit
CSC	360/Networks	1 course unit
CSC	370/Stack Machines	1 course unit
CSC	380/Artificial Intelligence	1 course unit
CSC	390/Programming Language	1 course unit
STA	115/Statistics I	1 course unit
MAT	315/Linear Algebra I	1 course unit
MAT	316/Probability	1 course unit
MAT	326/Differential Equations	1 course unit

Suggested First–Year Sequence (PHYC)

Fall Semester

FSP	First Seminar	1 course unit
PHY	099/Orientation to Physics	0 course unit
PHY	201/General Physics I	1 course unit
MAT	127/Calculus A	1 course unit
Liberal Learning		1 course unit

Spring Semester

PHY	202/General Physics II	1 course unit
CSC	220/Computational Problem Solving	1 course unit
MAT	128/Calculus B	1 course unit
WRI	102/Academic Writing* (if not exempted)	1 course unit

**It is recommended that students exempted from this course take another liberal learning course.*

Physics Major (PHYT)—Physics Teacher Preparation Track

An overview of the entire secondary-level teacher preparation sequence for students can be found in the section of this bulletin for the Department of Education Administration and Secondary Education.

Students planning to teach middle or high school physics should consult with their advisor in planning their academic program. These plans should take into account requirements for: the major, liberal learning, professional courses, and state certification. To be retained in the program, a student must earn at least a 2.5 cumulative grade point average before enrolling in the junior year education sequence. The student must establish a minimum 2.75 GPA in order to be allowed to student teach.

Candidates for a teacher-education certificate must have a 2.75 or higher cumulative grade point average to successfully complete their teacher education program. They also must meet the state hygiene/physiology requirement, and pass the appropriate Praxis examination before the New Jersey State Department of Education will issue the appropriate certificate. Teacher-education candidates will receive a "certificate of eligibility with advanced standing" which requires a candidate to be provisionally certified for his or her first year of teaching. After one year of successful teaching, the candidate is eligible for a permanent certificate

Required Major Courses (10 course units)

PHY	161/Introduction to Astronomy	1 course unit
PHY	120/Introduction to Geology	1 course unit
PHY	171/Introduction to Meteorology	1 course unit
PHY	099/Orientation to Physics	0 course unit
PHY	201, 202/General Physics I, II	2 course units
PHY	311/Analog and Digital Electronics	1 course unit
PHY	321/Modern Physics	1 course unit
PHY	390/Methods of Teaching Science	1 course unit
Two physics options (see below)		2 course units

Physics Options

PHY	306/Mathematical Physics	1 course unit
PHY	316/Biomedical Physics	1 course unit
PHY	393/Independent Research I	1 course unit
PHY	401/Classical Mechanics	1 course unit
PHY	411/Optics and Wave Motion	1 course unit
PHY	413/General Relativity and Cosmology	1 course unit
PHY	416/Thermodynamics	1 course unit
PHY	421/Electromagnetic Theory I	1 course unit
PHY	422/Electromagnetic Theory II	1 course unit
PHY	426/Particle and Nuclear Physics	1 course unit
PHY	431/Quantum Mechanics	1 course unit
PHY	436/Condensed Matter	1 course unit
PHY	451/Experimental and Analytical Physics	1 course unit
PHY	466/Astrophysics	1 course unit
PHY	493/Independent Research II	1 course unit

Required Correlates (seven course units)

CHE	201, 202/General Chemistry I, II	2 course units
CHE	Chemistry options (see below)	2 course units
CSC	215/Computer Science I OR 220/Computational Probem Solving	1 course unit
MAT	127, 128/Calculus A, B	2 course units

Chemistry Options

CHE	353, 354/Organic Chemistry I, II
CHE	371/Physical Chemistry
CHE	340/History of Chemistry and Physics
CHE	310/Analytical Chemistry

Professional Education Sequence:

SED	224/Adolescent Learning and Development	1 course unit
EFN	298/School and Communities	1 course unit
SED	399/Pedagogy in Secondary Schools	1 course unit
SPE	323/Secondary Content Literacy in Inclusive Classrooms	1 course unit
EFN	398/Historical and Political Context of Schools	1 course unit
PHY	490/Student Teaching	2 course units
SED	498/Collaborative Capstone for Professional Inquiry	1 course unit

Suggested First–Year Sequence (PHYT)

Fall Semester

FSP	First Seminar	1 course unit
PHY	099/Orientation to Physics	0 course unit
PHY	201/General Physics I	1 course unit
MAT	127/Calculus A	1 course unit
Liberal Learning		1 course unit

Spring Semester

PHY	202/General Physics II	1 course unit
CSC	215/Computer Science I OR 220/Computational Probem Solving	1 course unit
MAT	128/Calculus B	1 course unit
WRI	102/Academic Writing* (if not exempted)	1 course unit

**It is recommended that students exempted from this course take another liberal learning course.*

Physics Major PHYG—Earth Science Track

Required Courses (11 course units)

PHY	161/Introduction to Astronomy	1 course unit
PHY	120/Introduction to Geology	1 course unit
GEO	220/Advanced Geology	1 course unit
PHY	171/Introduction to Meteorology	1 course unit
PHY	099/Orientation to Physics	0 course unit
PHY	201, 202/General Physics I, II	2 course units

PHY	311/Analog and Digital Electronics	1 course unit
PHY	321/Modern Physics	1 course unit
Three physics options (see below)		3 course units

Physics Options

AST	261/Stellar Astronomy	1 course unit
PHY	306/Mathematical Physics	1 course unit
PHY	316/Biomedical Physics	1 course unit
PHY	393/Independent Research I	1 course unit
PHY	401/Classical Mechanics	1 course unit
PHY	411/Optics and Waves	1 course unit
PHY	413/General Relativity and Cosmology	1 course unit
PHY	416/Thermodynamics	1 course unit
PHY	421/Electromagnetic Theory I	1 course unit
PHY	422/Electromagnetic Theory II	1 course unit
PHY	426/Particle and Nuclear Physics	1 course unit
PHY	431/Quantum Mechanics	1 course unit
PHY	451/Experimental and Analytical Physics	1 course unit
PHY	466/Astrophysics	1 course unit
PHY	493/Independent Research II	1 course unit

Required Correlates (five course units)

CHE	201, 202/General Chemistry I, II	2 course units
CSC	215/Computer Science I OR	
	220/Computational Problem Solving	1 course unit
MAT	127, 128/Calculus A, B	2 course units

Suggested First–Year Sequence (PHYG)

FSP	First Seminar	1 course unit
PHY	099/Orientation to Physics	0 course unit
PHY	201, 202/General Physics I, II	2 course units
CSC	215/Computer Science I OR	
	220/Computational Problem Solving	1 course unit
MAT	127, 128/Calculus A, B	2 course units
WRI	102/Academic Writing (if not exempted) *	1 course unit
Liberal Learning		1 course unit

**It is recommended that students exempted from this course take another liberal learning course.*

Elementary Education and M/S/T and Early Childhood Education and M/S/T with a Physics Specialization

This interdisciplinary major integrates formal study in mathematics, science, and technology and consists of a common "core" with a "specialization" in one of the M/S/T disciplines. Students electing a physics specialization will complete 10 course units of common core requirements including MAT 127, 128/Calculus A, B, PHY 201, 202/General Physics I, II, one approved non-physics science course, TST 171/Fundamentals of Technology, TST 181/Structures and Mechanisms, TED 460/Integrated M/S/T for the Child/Adolescent Learner, and two M/S/T approved electives. The physics specialization consists of a minimum of three additional course units including PHY 321/Modern Physics, and PHY 306/Mathematical Physics and an advanced physics elective at the 400 level or above. See the M/S/T academic program coordinator for general advisement.

Physics Minor

A minor in physics requires a total of five course units. The required courses are PHY 201, 202/General Physics I and II, PHY 321/Modern Physics, and PHY 306/Mathematical Physics. One advanced physics course (400 level or higher) must be added with the approval of the department chair.

PHY 201, 202/General Physics I, II

PHY 306/Mathematical Physics

PHY 321/Modern Physics

One advanced course elected at the 400 level with the prior approval of the physics department chair.

Minimum grade point average for retention and completion of the minor is the same as for the major.

PHY 099/Orientation to Physics **0 course unit**
(every fall)
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 120/Introduction to Geology **1 course unit**
(with laboratory)
(every semester)
Same as GEO 120
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)
(every fall)
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 122/Selected Principles of Physics **1 course unit**
(with laboratory)
(every spring)
Restriction: Not for science or mathematics majors
Centered around selected principles related to the laws of physics. Emphasis is on a conceptual understanding of these topics as they relate to everyday life. Topics may include projectiles and satellite motion, air travel, alternative energy, wave motion, physics of sports, physics of automobiles, ballistics, photography, light, color, lenses and mirrors, eclipses, magnets, holograms, tides, radio and TV, rockets, electricity and physics of amusement parks.

PHY 161/Introduction to Astronomy **1 course unit**
(with laboratory)
(every semester)
Same as AST 161
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 properties, origin, and evolution of (1) the solar system, and (2) stars and stellar systems, including galaxies; and cosmology. Laboratory sessions will involve an investigation of observable celestial phenomena, including 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 included.

PHY 171/Introduction to Meteorology **1 course unit**
(with laboratory)
(fall semester)
Same as MET 171
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 127
Calculus-based introductory physics, first course of a two semester sequence designed for science and mathematics majors. 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)
Prerequisite: PHY 201
Prerequisite: MAT 127
Second part of two-semester calculus-based introductory course in electricity and magnetism, optics, and topics in modern physics. 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 laboratory experiences.

PHY 306/Mathematical Physics **1 course unit**
(annually—spring)
Prerequisites: PHY 202, MAT 128, and CSC 215 or equivalent, or permission of instructor
A study of the mathematical methods necessary to solve a variety of physics problems. Predictions of physical theories are used to design new experimental techniques and observational methods. Students are exposed to a large variety of mathematical methods used by both experimental and theoretical physicists. Application of multiple integrals in curvilinear coordinates, vector calculus, Fourier analysis, matrices, complex numbers. Course also introduces the use of Mathematica® as an aid in solving problems numerically, symbolically and graphically.

PHY 311/Analog and Digital Electronics **1 course unit**
(alternate 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**
(alternate years-spring)
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: electrical properties of nerve and muscle cells, conduction system of the heart, theory of electrocardiography, bio-magnetism, brain waves, 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, magnetic resonant imaging (MRI).

PHY 321/Modern Physics **1 course unit**
(with laboratory)
(every fall)
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 special theory of relativity, wave-particle duality, quantization of energy, Schrödinger equation, potential wells, and atomic physics. Experimental basis for modern physics is also discussed.

PHY 390/Methods of Teaching Science **1 course unit**
(every fall)
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 in physics, 2.5 overall GPA, and permission of faculty mentor and department chair
A student, in collaboration with a faculty member, will study an advanced topic in physics or a related field.

PHY 393/Independent Research I **1 course unit**
(every semester)
Prerequisite: Approval of supervising faculty member and department chair
Independent study in a selected area of physics, geology, meteorology or astronomy through the use of scientific journals, source books, and experimentation. This course is reserved for students of junior standing with a GPA of 2.5 or higher.

PHY 401/Classical Mechanics **1 course unit**
(alternate years)
Prerequisites: PHY 202, 306, CSC 215
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, Lagrangians, and Hamiltonians. Scientific programming is used extensively in problem solving.

PHY 411/Options and Wave Motion **1 course unit**
(alternate years)
Prerequisites: PHY 321, CSC 215, PHY 306 or permission of instructor
A study of the properties of light and its interaction with matter. Topics include 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**
(occasionally)
Prerequisite: PHY 306 or MAT 129
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 416/Thermodynamics **1 course unit**
(offered in alternate years)
Prerequisite: PHY 202, 306 and CSC 215 or equivalent
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 421/Electromagnetic Theory I **1 course unit**
(alternate years)
Prerequisites: PHY 306, MAT 326, CSC 215 or permission of instructor
The first part of this course is devoted to the conceptual understanding of the basic ideas of the theory. Then, a systematic approach of the development of the necessary equations will be considered. Topics to be addressed are: applications of Coulomb's Law, nature of the electric field, applications of Gauss' Law, potentials, conductors in electromagnetic fields, energy of the electromagnetic field, and special methods in electrostatics. The latter part of the course will be concerned with various applications of the theory.

PHY 422/Electromagnetic Theory II **1 course unit**
(alternate years)
Prerequisite: PHY 421, or permission of instructor
A study of the theory and laws of classical electromagnetism on an intermediate level. Emphasis will be given to electrostatic charge distributions, potential theory, Maxwell's equations, and electromagnetic waves.

PHY 426/Particle and Nuclear Physics **1 course unit**
(alternate years)
Prerequisites: PHY 306, 321, CSC 215 or equivalent
Fundamental concepts and applications of Particle and Nuclear Physics will be discussed, such as the standard model, the shell model of nuclei, accelerations, 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**
(alternate years)
Prerequisites: PHY 306, PHY 321, CSC 215 or equivalent
Fundamental concepts of quantum mechanics and applications to problems in modern physics. Wave mechanics and wave mechanical properties of matter studied using the Schroedinger approach. Problem solving and computer projects are integral parts of the course.

PHY 436/Condensed Matter **1 course unit**
(occasionally)
Prerequisites: PHY 321, PHYS 306
Corequisite: PHY 421
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/Experimental and Analytical Physics **1 course unit**
(alternate years)
Prerequisites: PHY 306, PHY 321, CSC 220
A team-taught course where students take part in experiments or projects of high caliber, comparable to actual research in the areas of expertise of the participating faculty member. The course consists of 1 lecture hour and 3 hours of laboratory per week. The lecture hour will be used to acquaint the students with the theory and principles of physics fundamental to the experiments to be done, and the methods to apply in analyzing the data. Some projects will involve collecting and analyzing data from the NASA data archives. Individual experiments may take more than one week to complete. Students will be expected to devote time every week to analyzing the data, which may entail using computer software that they will develop, and compiling the results into a formal report equivalent to a paper to be submitted for publication in a journal. Emphasis will be given to in-depth writing and literature search. Papers may be presented and discussed at departmental colloquia.

PHY 466/Astrophysics **1 course unit**
(occasionally)
Prerequisites: PHY 321, CSC 220
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 and galaxies and cosmology. An emphasis will be placed on the methodology employed by astrophysicists to investigate the stellar world.

PHY 493/Independent Research II **variable course units**
(every semester)
Prerequisite: Senior standing in physics, overall GPA of 2.5 and permission of faculty mentor and department chair
This writing-intensive 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.

AST 161/Introduction to Astronomy **1 course unit**
(with laboratory)
(every semester)
Same as PHY 161
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 properties, origin, and evolution of (1) the solar system, and (2) stars and stellar systems, including galaxies; and cosmology. Laboratory sessions will involve an investigation of observable celestial phenomena, including 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 included.

AST 261/Stellar Astronomy **1 course unit**
(with laboratory)
(alternate years)
Prerequisite: AST 161 or PHY 161
A study of the knowledge gained from the investigation of the stellar universe, that is, what is beyond the solar system. Topics include: the properties, structure, and evolution of stars, star clusters, galaxies and cosmology. An emphasis will be placed on the methodology employed by astrophysicists to investigate the stellar world. Laboratory sessions will deal with the gleaning and analysis of observational data. The laboratory experiences are facilitated by the use of interactive computer software in the astronomy lab and the telescopic and other equipment of the TCNJ observatories, which are state-of-the-art.

GEO 120/Introduction to Geology **1 course unit**
(with laboratory)
(every semester)
Same as PHY 120
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.

GEO 220/Advanced Geology **1 course unit**
(with laboratory)
(alternate years)
Same as PHY 220
Prerequisite: GEO 120 or PHY 120
Earth history as recorded by the rock record is emphasized. Topics include: determining Earth origin and age, sediments and sedimentary structures, marine and non-marine environments of deposition, and Geologic time. Field trips to the following locations are required: The American Museum of Natural History, Sterling Hill Mine, Central New Jersey, Northern New Jersey, and Eastern Pennsylvania. Small fees are associated with each trip.

MET 171/Introduction to Meteorology **1 course unit**
(with laboratory)
(fall semester)
Same as PHY 171
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.