

## Physics

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Click here for [Physics courses](#).

The objectives of the department are to develop the student's comprehension of the basic principles of physics, to develop analytical and problem-solving skills, to instill a sense of inquiry in the student, 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 curriculum is designed to prepare students for graduate study in physics and related fields as well as to provide students with a foundation for work in education or the private sector.

Two degree paths are offered within the major: a B.S. in Physics-Liberal Arts and a B.S. in Physics-Secondary Education. The physics requirements of both degree paths are the same. The department also offers major specializations within the B.S. Physics-Liberal Arts: Pre-graduate physics, Astrophysics, Biomedical Physics, Computational Physics, Geophysics, and Physical Sciences Secondary Education. Self-designed specializations are also possible. The department encourages all students to engage deeply in the major through research opportunities within the department and to broaden their liberal education by exploring opportunities for liberal learning concentrations, minors, and study abroad experiences.

### Physics: Liberal Arts

The requirements of the physics major consist of the following courses:

1. **7 Core Courses:** A fixed core of physics courses, regardless of degree path or specialization. Core courses may not be double counted in any other category.
  - PHY 201/General Physics I
  - PHY 202/General Physics II
  - PHY 306/Mathematical Physics I
  - PHY 321/Modern Physics
  - PHY 401/Classical Mechanics
  - PHY 416/Thermodynamics
  - PHY 421/Electromagnetic Theory I
2. **5 Physics Options:** 200-level or higher physics (PHY prefix) courses
  - Specifications:*
    - One course must have a lab component.
    - Independent research may be one of these courses, but does not satisfy the requirement for a lab-based option course.
    - These 5 courses may not double-count in any other category, with the exception of the capstone course.
3. **2 Correlates:** MAT127/Calculus A and MAT128/Calculus B (or AP credit).
4. **5 Specialization Options:** Elective courses to be used toward specialization and breadth.
  - Specifications:*
    - These may be any courses from the school of science or engineering.
    - At least two must be 200-level or higher
    - Two of the 5 courses may be from the school of education for secondary education students
    - One of these five courses may be independent research.

- These 5 courses may not double-count in any other category, with the exception of the capstone course.
5. **1 Capstone:** PHY493, PHY451, or SED498. This course may also be counted toward category 2 or 4 above.

### **Physics: Secondary Education**

The Physics-Secondary Education program prepares students to become teachers of physics in the secondary public schools of New Jersey and many other states. It includes a liberal learning component, a strong and broad foundation in the content area with an emphasis in physics, as well as professional experience both in the classroom and in the field. Upon completion of the basic program, students are prepared for certification in physics in New Jersey. 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.

The courses listed below are the required of all Physics-Secondary Education students, however, most of these courses can be counted toward major or liberal learning requirements (as noted in parentheses). While it can be challenging to fulfill the secondary education program and one of the five pre-set major specializations, it can be done through careful advisement and course selection. One additional specialization is also available to secondary education students who wish to prepare for certification in Physics and Physical Science.

### **Required Courses**

CHE	201/General Chemistry I (may count as a specialization option)
SED	224/Adolescent Learning & Development (also counts as social science L.L.)
EFN	299/School & Communities (also counts as social science L.L.)
SPE	323/Secondary Content Literacy in Incl. Classes* (may count as specialization option)
SED	399/Pedagogy in Secondary Schools*(may count as specialization option)
PHY	390/Methods of Teaching Science* (counts as a physics option course)
EFN	98/Historical & Political Contexts in Schools
PHY	490/Student Teaching (counts as 2 physics options)
SED	498/Collaborative Capstone for Inquiry (capstone)

\*These three courses are typically taken together during the fall of the junior year.

Other Recommended Courses: It is strongly advised that all prospective teachers also take General Chemistry II as a specialization option course.

## Major Specializations

Through choices in items 2, 4, 5, and students may complete a seven course “*specialization*,” which is decided by advisement and is intended to be visible on the student transcript. The major requires a total of 10 option courses (items 2 and 4); 7 of these may be chosen so as to fulfill one of the pre-set major specializations described below. A self-designed specialization may also be chosen with advisement. While all physics students are encouraged to choose a specialization within the major, it is not a requirement for graduation.

### Specialization A: Pre-graduate Physics

Students in this specialization will acquire an excellent theoretical and experimental background that prepares them for graduate study in physics or astrophysics. Graduates can also find career placements in industrial or national laboratories for research and development.

It is recommended that students take the following courses:

MAT	326/Differential Equations
PHY	422/Electromagnetic Theory II
PHY	431/Quantum Mechanics
CSC	215/Computer Science I for Science and Engineering or CSC 220/Comp. Problem Solving

Three additional courses in physics, chemistry, or mathematics. At least two of which must be at the 300 or 400 level.

### Specialization C: Computational Physics

Students with an interest in both physics and computer science should consider this specialization. Students will acquire a college-level understanding of the laws governing the universe. They will also be trained in the art of analyzing and solving difficult problems. In the Junior and Senior years students are assigned projects that acquaint them with the techniques of computer modeling and using the computer to solve problems. Computers are necessary since some problems are impossible to solve completely using calculus. In addition, students will take courses in computer science that will enable them to acquire a deeper understanding of how the computer works and how to use it more efficiently. The graduate of this program will be prepared for a career in technical and/or scientific software development. Some graduates, by proper choice of electives, enroll in graduate physics or graduate computer science programs.

Students who elect to specialize in Computational Physics are encouraged to take as many Computer Science courses as possible. However, it is recommended that they take at least the following five courses:

CSC	215/Computer Science I
CSC	220 /CS I – Computational Problem Solving
CSC	230 /CS II – Data Structures
CSC	260 /CS III – Programming in the Large
CSC	310 /Discrete Structures of Computer Science

**and**

Two additional course in the school of science, by advisement

### Specialization G: Geophysics

Students with an interest in the physical earth sciences can complete a specialization in geophysics. Students following this specialization will be trained with eye toward a possible career or graduate study in one of the following areas: Seismology, Volcanology, Geochemistry, Bio-geoscience, Environmental Science, Meteorology, Climatology, Climate Change Science, Oceanography, Aeronomy, Planetary Sciences, Mineralogy Petrology, Hydrology, and Geodesy.

Students in this specialization will be exposed to multiple independent research opportunities in cutting-edge areas of geophysics research and invited to participate in national conferences. In addition to a core education in physics, students will be challenged to apply physical laws to the earth system.

It is recommended that students take the following courses:

PHY	120/Introduction to Geology
PHY	171/Introduction to Meteorology
CHE	201/Introduction to Chemistry
PHY	220/Advanced Geology (course revision likely)
PHY	393/Independent Research I (in geophysics)
Two other 200+ level science or engineering courses by advisement.	

A new course in atmospheric physics is planned for the future and would be included in the above list.

### **Specialization H: Biomedical Physics**

This specialization offers an opportunity for students to enhance their education in biology, chemistry, and bioengineering, while using their physics skills and analytical problem solving abilities. Such students are often interested in careers in medicine, biology, biophysics, or medical physics. Other students may be interested in the development of the next generation of equipment and software for the detection and cure of disease; in research of materials that can be used in the human body; or in science and technology used in solving clinical problems. Premedical students with interest in radiology, cardiology, neurology, and ophthalmology should find the course sequence especially valuable. This specialization satisfies the general medical school admission requirements when proper choices of options and electives are made. The courses in the Biomedical Physics specialization uphold the rigor of TCNJ physics major, while allowing adequate flexibility in choosing among the option courses. For example, students interested in nuclear medicine can take the Nuclear Physics course. Students interested in ophthalmology would be well served by choosing the Optics course.

It is recommended that students take all six of the following courses:

PHY	316/Biomedical Physics
CHE	201/General Chemistry I
CHE	202/General Chemistry II
BIO	185/Themes in Biology
BIO	211/Biology of the Eukaryotic Cell
BME	251/Introduction to Biomedical Engineering

**and** at least one of the following courses, depending on their interests and goals\*:

BIO	231/Genetics (with lab)
BIO	332/Comparative Vertebrate Anatomy (with lab)
CHE	331/Organic Chemistry I
BME	311/Physiological Systems
ENG	272/Advanced Engineering Math I
ELC	321/Signals and Systems (ENG 272 is a prerequisite)

*\* Students who are considering a career in medicine should note that medical school admissions typically require two semesters of biology with lab and two semesters of organic chemistry. It is commonly recommended that students select additional courses from this list with free electives.*

### **Specialization S: Astrophysics**

This specialization is designed for those students who have an interest in astronomy and astrophysics, and who wish to pursue a career in these fields. Usually such students are planning

to further their studies in graduate school in astrophysics or physics. There are also job opportunities for baccalaureate level graduates at planetariums, science museums, NASA facilities, and national observatories.

It is recommended that students take the following courses:

PHY 161/Introduction to Astronomy  
 PHY 261/Advanced General Astronomy (formerly Stellar Astronomy)  
 PHY 466/Introduction to Astrophysics  
 PHY 413/General Relativity & Cosmology  
 PHY 393/Independent Research I (in astronomy)  
 Two other physics courses by advisement.

### **Specialization T2: Physical Science Secondary Education, for Secondary Education students only)**

With several additional courses, secondary education students may also prepare for physical science certification, which can broaden school placement options. The following set of additional courses may be selected to prepare students for certification in Physical Science. A physical science certification is important for those wishing to broaden employment options, including those interested in teaching science in middle schools. With use of the one remaining SOS option, at least 1 advanced earth science course as a PHY option, and free electives, this dual certification preparation option can still be completed within the 32 total course units.

CHE 202/General Chemistry II  
 2 additional chemistry courses  
 Three of the following 6 courses:  
 PHY 120/Introduction to Geology  
 PHY 161/Introduction to Astronomy  
 PHY 171/Introduction to Meteorology  
 PHY 220/Advanced Geology  
 PHY 261/Stellar Astronomy  
 PHY 466/Astrophysics

### **Recommended First-Year course sequence**

The following sequence of courses is recommended for most entering freshmen. Depending on high school coursework and AP credits, individual adjustments may be advised.

Freshman Year			
Fall courses	Fulfills Req.	Spring courses	Fulfills Req.
Freshman Seminar (0 credit)	Core 0	General Physics II	Core 2
General Physics I	Core 1	Calculus B	Correlate 2
Calculus A	Correlate 1	Language	Language 2
Language	Language 1	Specialization Option	Specialization 1
FSP	Liberal Learning 1		

### **Liberal Learning**

The liberal learning requirements for students in the physics major conform to the College's liberal learning policies and recommendations.

For details, see <http://www.tcnj.edu/~liberal/define.html>

Several important nuances of liberal learning apply to specifically to physics majors:

#### **1. Option A: Designated Interdisciplinary Concentration:**

The Environmental Studies Concentration can count several physics courses. See <http://www.tcnj.edu/~liberal/concentrations/environ.html> for details.

**2. Option C: Breadth Distribution:**

- The Natural Sciences and Quantitative Reasoning Requirements are fully satisfied by major requirements.
- For secondary education students, two of the Social Sciences and History requirements are satisfied by required education courses in the category of Behavioral, Social or Cultural Perspectives.

**3. Language Requirement:**

Physics majors are required to progress through 3<sup>rd</sup> level proficiency (103) with one exception: the Secondary Education program, has a slightly different language requirement than is typical. If beginning a new language, only 2 courses (101 and 102) are required for secondary education students. If continuing a language previously studied and entering the language at TCNJ at the 102 or 103 level, then 3<sup>rd</sup> level (through 103) proficiency is required.

**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 International and Off-Campus 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 Concentration for M/S/T major**

The M/S/T interdisciplinary major integrates formal study in mathematics, science, and technology to gain a better understanding of the human designed world in which we all live. The major consists of nine (9) units of courses drawn from a common “core”, one (1) approved M/S/T elective, and a four (4) unit “specialization” in one of the M/S/T disciplines. Students in the major receive careful course selection advisement so that they qualify for a middle school endorsement in one of the M/S/T disciplines.

**All majors must see the M/S/T academic program coordinator for general advisement.**

Students electing a Physics Specialization will complete:

MAT 127,128/Calculus A, B

PHY 201,202 General Physics I,II

One approved non-physics science course

ETE 261/Multimedia Design

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ETE 271/Structures and Mechanics

MAT 105/Mathematical Structures and Algorithms for Educators I

TED 460/Integrated M/S/T for the Child/Adolescent Learner

One M/S/T approved electives.

The physics specialization consists of three additional course units selected from the following:

PHY 120/Introduction to Geology

PHY 161/Introduction to Astronomy

PHY 171/Introduction to Meteorology

PHY 311/Analog and Digital Electronics

PHY 321/Modern Physics

An approved elective supporting the middle school endorsement.

### **Suggested Course Sequence M/S/T-Physics Specialization**

#### **Freshman Year (by advisement)**

FSP	First Seminar	1 course unit
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MAT	127/Calculus A	1 course unit
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TST	161/Creative Design	1 course unit
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ETE	261/Multimedia Design	1 course unit
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Science Option #1 (by advisement)		1 course unit
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Math or Science Option (by advisement)		1 course unit
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MAT	105/Mathematical Structures and Algorithms for Education I	1 course unit
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WRI	102/Academic Writing (if not exempt)*	1 course unit
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*\*It is recommended that students exempted from this course take another liberal learning course.*

#### **Total for year8 course units**

### **Physics Minor**

A minor in physics requires a total of five course units. The required courses are:

PHY 201/General Physics I

PHY 202/General Physics 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.