The Bachelor of Science in Physics with a concentration in pre-medical requires a minimum of 120 credits. The curriculum prepares students for a health sciences career using physics-based technologies. Students from this program who apply to medical school will have a distinctively rigorous preparation. The curriculum also prepares students for graduate medical physics, biomedical engineering and M.D.-Ph.D. programs.

Student learning outcomes

Students will learn to perform scientific reasoning and complex problem-solving. Physics majors will receive a fundamental understanding of the main areas of physics so that they are prepared for jobs that use physics-based technologies. They are expected to have mastered the analytical approach to solving technical problems by identifying simple subsystems that obey known physical laws and using these laws to approximate the behavior of the whole system.

Students will demonstrate a fundamental understanding of the main areas of physics.

Students will demonstrate communication skills, both written and oral, needed to explain the analysis of technical problems.

Students will demonstrate scientific literacy skills including searching, reading and critically reviewing scientific publications.

Students will demonstrate proficiency in information processing by generating and interpreting data presented in tables, graphs, drawings and models.

Double major in engineering and physics

A detailed description of this program (http://bulletin.vcu.edu/undergraduate/engineering/double-major-physics/) can be found in the “College of Engineering” section of this bulletin.

Students must complete 40 credits in physics and physics-related electives and 42 credits in ancillary requirements.

Degree requirements for Physics, Bachelor of Science (B.S.) with a concentration in premedical

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS 208</td>
<td>University Physics II</td>
<td>5</td>
</tr>
<tr>
<td>PHYS 301</td>
<td>Classical Mechanics I</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 320</td>
<td>Modern Physics &amp; PHYZ 320 Modern Physics Laboratory</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 340</td>
<td>Statistical Mechanics and Thermodynamics</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 376</td>
<td>Electromagnetism I</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 380</td>
<td>Quantum Physics I</td>
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</tr>
<tr>
<td>PHYS 440</td>
<td>Introduction to Condensed Matter Physics</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 450</td>
<td>Senior Physics Laboratory</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 490</td>
<td>Seminar in Conceptual Physics</td>
<td>1</td>
</tr>
<tr>
<td>PHYS 317</td>
<td>Preparing for the MCAT and Medical Sciences</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 335</td>
<td>Experimental Skills for Physicists</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 417</td>
<td>Topics in Biophysics</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 591</td>
<td>Topics in Physics (with topic of bioanalytics and data science)</td>
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</table>

Ancillary requirements

<table>
<thead>
<tr>
<th>Course</th>
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<tbody>
<tr>
<td>BIOL 151</td>
<td>Introduction to Biological Sciences I</td>
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<td>BIOZ 151</td>
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<td>BIOL 152</td>
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<td>&amp; BIOZ 152</td>
<td>Introduction to Biological Science Laboratory II</td>
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</tr>
<tr>
<td>CHEM 101</td>
<td>General Chemistry I and General Chemistry Laboratory I</td>
<td>4</td>
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<tr>
<td>&amp; CHEZ 101</td>
<td>General Chemistry II and General Chemistry Laboratory II</td>
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</tr>
<tr>
<td>CHEM 102</td>
<td>General Chemistry II and General Chemistry Laboratory II</td>
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<tr>
<td>&amp; CHEZ 102</td>
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<td>CHEM 301</td>
<td>Organic Chemistry</td>
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<td>&amp; CHEZ 301</td>
<td>Organic Chemistry I</td>
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<tr>
<td>CHEM 302</td>
<td>Organic Chemistry</td>
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<tr>
<td>&amp; CHEZ 302</td>
<td>Organic Chemistry I</td>
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<tr>
<td>MATH 200</td>
<td>Calculus with Analytic Geometry I (satisfies general education BOK for natural sciences and AOI for scientific and logical reasoning)</td>
<td>4</td>
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<tr>
<td>MATH 201</td>
<td>Calculus with Analytic Geometry II</td>
<td>4</td>
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<tr>
<td>MATH 301</td>
<td>Differential Equations</td>
<td>3</td>
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<tr>
<td>MATH 307</td>
<td>Multivariate Calculus</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 207</td>
<td>University Physics I (satisfies general education BOK for natural sciences and AOI for scientific and logical reasoning)</td>
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Experiential fine arts 1 1-3

Foreign language through the 102 level (by course or placement) 0-6

Open electives

Select any course. 7-15

Total Hours 120

1

Course offered by the School of the Arts

The minimum number of credit hours required for this degree is 120.
Freshman year  

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course Code</th>
<th>Course Name</th>
<th>Hours</th>
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<tr>
<td>Fall semester</td>
<td>BIOL 151</td>
<td>Introduction to Biological Sciences I</td>
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<td>BIOZ 151</td>
<td>Introduction to Biological Science Laboratory I</td>
<td>1</td>
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<tr>
<td></td>
<td>CHEM 101</td>
<td>General Chemistry I (satisfies general education AOI for scientific and logical reasoning)</td>
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<td>CHEZ 101</td>
<td>General Chemistry Laboratory I</td>
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<td>MATH 200</td>
<td>Calculus with Analytic Geometry I (satisfies general education quantitative foundations)</td>
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<tr>
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<td>UNIV 111</td>
<td>Focused Inquiry I (satisfies general education UNIV foundations)</td>
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Experiential fine arts 1-3  

**Term Hours:** 16-18

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course Code</th>
<th>Course Name</th>
<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>Spring semester</td>
<td>BIOL 152</td>
<td>Introduction to Biological Sciences II</td>
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<tr>
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<td>&amp; BIOZ 152</td>
<td>and Introduction to Biological Science Laboratory II</td>
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<tr>
<td></td>
<td>HUMS 202</td>
<td>Choices in a Consumer Society</td>
<td>1</td>
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<td></td>
<td>MATH 201</td>
<td>Calculus with Analytic Geometry II</td>
<td>4</td>
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<tr>
<td></td>
<td>PHYS 207</td>
<td>University Physics I (satisfies general education BOK for natural sciences and AOI for scientific and logical reasoning)</td>
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<tr>
<td></td>
<td>UNIV 112</td>
<td>Focused Inquiry II (satisfies general education UNIV foundations)</td>
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**Term Hours:** 17

Sophomore year  

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<td>CHEM 102</td>
<td>General Chemistry II</td>
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<td>&amp; CHEZ 102</td>
<td>and General Chemistry Laboratory II</td>
<td>4</td>
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<tr>
<td></td>
<td>MATH 307</td>
<td>Multivariate Calculus</td>
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<tr>
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<td>PHYS 208</td>
<td>University Physics II</td>
<td>5</td>
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<tr>
<td></td>
<td>UNIV 200</td>
<td>Inquiry and the Craft of Argument (satisfies general education UNIV foundations)</td>
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**Term Hours:** 16

<table>
<thead>
<tr>
<th>Semester</th>
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<th>Hours</th>
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<tr>
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<td>CHEM 301</td>
<td>Organic Chemistry</td>
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<td>&amp; CHEZ 301</td>
<td>and Organic Chemistry Laboratory I</td>
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<td>MATH 301</td>
<td>Differential Equations</td>
<td>3</td>
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<td>Classical Mechanics I</td>
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<td>PHYS 320</td>
<td>Modern Physics</td>
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**Term Hours:** 15

Junior year  

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<th>Semester</th>
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<th>Course Name</th>
<th>Hours</th>
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<tbody>
<tr>
<td>Fall semester</td>
<td>CHEM 302</td>
<td>Organic Chemistry</td>
<td>5</td>
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<td></td>
<td>&amp; CHEZ 302</td>
<td>and Organic Chemistry Laboratory II</td>
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**Term Hours:** 15

Senior year  

<table>
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<th>Semester</th>
<th>Course Code</th>
<th>Course Name</th>
<th>Hours</th>
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<tbody>
<tr>
<td>Fall semester</td>
<td>PHYS 417</td>
<td>Topics in Biophysics</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>PHYS 440</td>
<td>Introduction to Condensed Matter Physics</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>PHYS 450</td>
<td>Senior Physics Laboratory</td>
<td>3</td>
</tr>
<tr>
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<td>General education course (select BOK to complete breadth of knowledge requirement and AOI for diversities in the human experience)</td>
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**Term Hours:** 12

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course Code</th>
<th>Course Name</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring semester</td>
<td>PHYS 490</td>
<td>Seminar in Conceptual Physics</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>PHYS 591</td>
<td>Topics in Physics (with topic of bioanalytics and data science)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>General education course (select BOK to complete breadth of knowledge requirement and AOI for for global perspectives)</td>
<td>3</td>
</tr>
</tbody>
</table>

Open electives 8-9  

**Term Hours:** 15-16

**Total Hours:** 120-123

The minimum number of credit hours required for this degree is 120.

- Physics (PHYS) (p. 2)
- Physics labs (PHYZ) (p. 4)

**Physics**  

**PHYS 101. Foundations of Physics. 3 Hours.**  
Semester course; 3 lecture hours. 3 credits. For non-science majors. Introduction to the fundamental ideas of physics. The course covers selected topics in mechanics, heat, optics, electricity and magnetism, and modern physics. Not applicable toward the physics major. An optional laboratory may be taken with this course; see PHYZ 101.

**PHYS 103. Elementary Astronomy. 3 Hours.**  
Semester course; 3 lecture hours. 3 credits. A descriptive approach to astronomy dealing with basic features of our solar system, our galaxy and the universe. Not applicable toward physics major. An optional laboratory may be taken with this course; see PHYZ 103.
PHYS 107. Wonders of Technology. 4 Hours.
Semester course; 5 lecture/laboratory/recitation hours. 4 credits.
Introduction to physics concepts involved in everyday technological applications. The course covers selected topics in mechanics, heat, optics, electricity and magnetism, and modern physics by depicting their role in common devices. The laboratory focuses on applications of physics principles to everyday real-life situations. Not applicable toward the physics major.

PHYS 201. General Physics I. 4 Hours.
Semester course; 3 lecture and 3 laboratory hours. 4 credits. Prerequisite: MATH 151. Designed primarily for life-science majors. Basic concepts of motion, waves and heat. Not applicable toward the physics major.

PHYS 202. General Physics II. 4 Hours.
Semester course; 3 lecture and 3 laboratory hours. 4 credits. Prerequisite: PHYS 201 or PHYS 207. Designed primarily for life-science majors. Basic concepts of electricity, magnetism, light and modern physics. Not applicable toward the physics major.

PHYS 207. University Physics I. 5 Hours.
Semester course; 3 lecture, 1 recitation and 3 laboratory hours. 5 credits. Prerequisite: PHYS 207. Corequisite: MATH 201. A vector- and calculus-based introduction to the fundamental concepts of mechanics, heat and wave motion.

PHYS 208. University Physics II. 5 Hours.
Semester course; 3 lecture, 1 recitation and 3 laboratory hours. 5 credits. Prerequisite: PHYS 207. Corequisite: MATH 201. A vector- and calculus-based introduction to the fundamentals of electricity, magnetism and optics.

PHYS 211. Physical Analysis. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: MATH 201 and PHYS 208. Corequisite: MATH 307. Extends the discussion of physical phenomena introduced in prerequisite courses to introduce topics and skills needed for more advanced physics courses. Topics include applying complex analysis to wave motion and oscillations, methods to solve problems in mechanics and an introduction to classical thermodynamics using multivariate analysis.

PHYS 215. Science, Technology and Society. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Examination of scientific breakthroughs that have led to transformational technologies that are continuing to impact society today. Topics include a historical perspective, an understanding of scientific principles and technologies and an examination of how such discoveries have changed society. Not applicable toward physics major.

PHYS 291. Topics in Physical Science. 1-3 Hours.
Semester course; 1-3 lecture or laboratory hours. 1-3 credits per semester. A study of a selected topic in physics, astronomy, geology, meteorology or oceanography. Not applicable toward physics major. See the Schedule of Classes for specific topics to be offered each semester and prerequisites.

PHYS 301. Classical Mechanics I. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: PHYS 208 and MATH 307. Corequisite: MATH 301. Review of vector calculus. Newtonian mechanics: single particle, oscillations, motion under central forces and dynamics of a systems of particles.

PHYS 302. Classical Mechanics II. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: PHYS 301 and MATH 301. Motion in noninertial frames, dynamics of rigid bodies, coupled oscillators, continuous systems and wave equations in one dimension.

PHYS 307. The Physics of Sound and Music. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: A 100- or 200-level physics course or equivalent and the ability to read music or sing or play a musical instrument, or permission of instructor. Basics of the physics of waves and sound. Fourier synthesis, tone quality, human ear and voice, musical temperament and pitch, physics of musical instruments, electronic synthesizers, sound recording and reproduction, room and auditorium acoustics. Not applicable toward the physics major. Crosslisted as: MHIS 307.

PHYS 315. Energy and the Environment. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Enrollment restricted to non-physics majors with junior or senior standing; not applicable to the physics major. A study of society's demands for energy, how it is currently being met, the environmental consequences thereof and some discussion of alternatives. Crosslisted as: ENVS 315.

PHYS 317. Preparing for the MCAT and Medical Sciences. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: BIOL 152, CHEM 102, PHYS 202 or PHYS 208. This course introduces physics majors to areas of medical practice where physical sciences play a key role. These include but are not limited to radiology and radiation oncology, orthopedics, pulmonology, and electrophysiology. Students will also review key topics in physics and life sciences that are tested on the Medical College Admissions Test. Broadly, these include chemical and physical foundations of biological systems as well as biological and biochemical foundations of living systems.

PHYS 320. Modern Physics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: PHYS 208 and MATH 307. Corequisite: MATH 301. Foundations of modern physics including special relativity, thermal radiation and quantization, wave-particle duality of radiation and matter, Schrödinger equation, atomic, nuclear and particle physics, and molecular structure and spectra. A continuation of PHYS 208.

PHYS 325. Visualization of Physics Using Mathematica. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: PHYS 208 and MATH 307. Corequisite: MATH 301. Visualization of various areas of physics using the Mathematica language for performing numerical calculations and producing graphics and animations. Examples will be taken from classical mechanics, classical electromagnetism, modern physics, statistical mechanics and condensed matter physics.

PHYS 335. Experimental Skills for Physicists. 3 Hours.
Semester course; 2 lecture and 2 laboratory hours. 3 credits. Prerequisites: PHYS 320 and PHYZ 320. Practical skills in experimental physics, including use of micro controllers, sensor modules, high-precision positions and opto-electronics. Skills will be used to address engaging and current real-world challenges.

PHYS 340. Statistical Mechanics and Thermodynamics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: PHYS 301 and MATH 301. Microscopic theory of temperature, heat and entropy, kinetic theory, multicomponent systems, and quantum statistics. Mathematical relationships of thermodynamics.

PHYS 351. Guided Inquiry for University Physics I. 1.5 Hour.
Semester course; 1 lecture and 1 recitation hour. 1.5 credits. Prerequisites: PHYS 207 and permission of instructor. Student learning assistants aid in recitation sections of PHYS 207 University Physics I using guided inquiry and group-based activities. Further develops the core skills of PHYS 207. Introduces students to the principles of active and collaborative learning in physics through practical, hands-on problem-solving, class discussions and demonstrations.
Physicists and their symmetries.
Structure of atoms, collision theory, nuclear structure, elementary
independent perturbation theory, relativistic hydrogen atom and the
multi-electron atoms—ground state, X-ray and optical excitations, time

PHYS 376. Electromagnetism. 3 Hours.
I Semester course; 3 lecture hours. 3 credits. Prerequisites: PHYS 301 and
MATH 301. Electrostatics, magnetism and electromagnetic
properties of matter, Maxwell’s equations, electromagnetic waves,
boundary conditions, and polarization.

PHYS 377. Electromagnetism II. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: PHYS 376.
Advanced topics in electromagnetism, such as the microscopic
theory of magnetism, slowly varying currents, physics of plasmas,
electromagnetic properties of superconductors, Maxwell’s equations
and propagation of electromagnetic waves in bounded media, dispersive
media, electromagnetic radiation, electrodynamics of moving charges,
and the relativistic formulation of electrodynamics.

PHYS 380. Quantum Physics I. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: PHYS 301,
PHYS 320 and MATH 301, or permission of instructor. Brief introduction
to the correspondence between classical and quantum mechanics,
Schroedinger wave equation, operator methods in quantum mechanics,
angular momentum and conservation laws, solution to harmonic
oscillator and the hydrogen atom, magnetic dipole moment and spin.

PHYS 391. Topics in Physics. 1-3 Hours.
Semester course; 1-3 lecture hours. 1-3 credits per semester. Maximum
total of 6 credits. In-depth study of a selected topic in physics or physics-
related technology, usually at a level requiring only elementary algebra.
Not applicable toward physics major. See the Schedule of Classes for
specific topics to be offered each semester and prerequisites.

PHYS 397. Directed Study. 1-3 Hours.
Semester course; variable hours. 1-3 credits per semester. Maximum of
3 credits applicable toward physics major requirement; maximum total
of 4 credits. Open to nonmajors. Determination of amount of credit and
permission of instructor must be obtained before registration of course.
Intended to allow nonmajors and majors to examine in detail an area of
physics or physics-related technology not otherwise available in upper-
level courses. May involve either directed readings or directed laboratory
work.

PHYS 417. Topics in Biophysics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: PHYS 208,
CHEM 102 and BIOL 152. An introduction to biophysics examining many
topics in life sciences. The course will introduce how to understand
phenomena in life sciences from a quantitative perspective and use
physical models for complex systems. Topics include Brownian motion,
mechanical and chemical equilibrium, electrostatics, molecular machines,
pattern formation and physical tools in biology.

PHYS 420. Quantum Physics II. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: PHYS 380 or
permission of instructor. Transition rates, addition of angular momentum,
multi-electron atoms—ground state, X-ray and optical excitations, time
independent perturbation theory, relativistic hydrogen atom and the
structure of atoms, collision theory, nuclear structure, elementary
particles and their symmetries.

PHYS 422. Optics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: PHYS 376 or
permission of instructor. Comprehensive study of propagation of light,
including geometrical optics, polarization, interference, diffraction, Fourier
optics and quantum optics.

PHYS 440. Introduction to Condensed Matter Physics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: PHYS 340 and
380. Corequisite: PHYS 376. Structure and bonding in solids, phonons,
free electron Fermi gas, energy bands, semiconductors, Fermi surface,
optical properties and magnetism.

PHYS 450. Senior Physics Laboratory. 3 Hours.
Semester course; 1 lecture and 4 laboratory hours. 3 credits.
Prerequisites: PHYS 301 and 320, and PHYZ 320. Experiments in
condensed matter physics with an introduction to the instrumentation
and data analysis used in the research laboratory.

PHYS 480. Particle Physics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: PHYS 340,
PHYS 376 and PHYS 420. Basic concepts of particle physics, including
the Dirac equation, lowest-order quantum electrodynamics calculations,
scattering amplitudes and cross sections, the weak interaction,
processes involving quarks and their symmetries, and quantum
chromodynamics.

PHYS 483. Introduction to Astrophysics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: PHYS 340,
PHYS 376 and PHYS 380. Pre- or corequisites: PHYS 376 and PHYS 380. Basic concepts of
star formation and evolution, galactic structures, and cosmology.
Includes stellar atmospheres and interiors, the sun, the Milky Way and
other galaxies, and black holes.

PHYS 490. Seminar in Conceptual Physics. 1 Hour.
Semester course; 1 lecture hour. 1 credit. Prerequisites: PHYS 340,
PHYS 376, PHYS 380 and PHYZ 320. Restricted to seniors in physics
with at least 85 credit hours taken toward the degree. A senior capstone
course in physics designed to help students formulate physics-related
questions in such a way that they can obtain quantitative answers.
Students will describe their results in a senior paper and in an oral
presentation.

PHYS 491. Topics in Physics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Maximum of 3 credits
applicable toward physics major requirement; maximum total
of 6 credits. Open to nonmajors. Determination of amount of credit and
permission of instructor must be obtained before registration of course.
Intended to allow nonmajors and majors to examine in detail an area of
physics or physics-related technology not otherwise available in upper-
level courses. May involve either directed readings or directed laboratory
work.

PHYS 492. Independent Study. 1-3 Hours.
Semester course; variable hours. 1-3 credits per semester. Maximum of
3 credits applicable toward physics major requirement; maximum total
of 6 credits. Open to nonmajors. Determination of amount of credit and
permission of instructor must be obtained before registration of course.
Intended to allow nonmajors and majors to examine in detail an area of
physics or physics-related technology not otherwise available in upper-
level courses. May involve either directed readings or directed laboratory
work.

PHYS Z101. Foundations of Physics Laboratory. 1 Hour.
Semester course; 2 laboratory hours. 1 credit. Corequisite: PHYS 101. An
optional laboratory consisting of experiments and activities correlated
with PHYS 101.
PHYZ 103. Elementary Astronomy Laboratory. 1 Hour.
Semester course; 2 laboratory hours. 1 credit. Pre- or corequisite:
PHYS 103. An optional laboratory course consisting of experiments and
activities related to PHYS 103.

PHYZ 320. Modern Physics Laboratory. 1 Hour.
Semester course; 3 laboratory hours. 1 credit. Pre- or corequisite:
PHYS 320. Experimental work correlated with PHYS 320.