PHYSICS, BACHELOR OF SCIENCE (B.S.)

The Bachelor of Science in Physics requires a minimum of 120 credits, including 54 credits in physics and physics-related courses, as detailed in the course lists.

The curriculum in physics prepares students for technical careers in physics or an allied area, for careers in engineering and for the teaching of physics in secondary schools. The curriculum also prepares students for graduate studies in physics or a related area.

Student learning outcomes

Upon completing this program, students will know how to do the following:

• 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.

• Demonstrate a fundamental understanding of the main areas of physics

• Demonstrate communication skills, both written and oral, needed to explain the analysis of technical problems

• Demonstrate scientific literacy skills including searching, reading and critically reviewing scientific publications

• 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.

Degree requirements for Physics, Bachelor of Science (B.S.)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select 30 credits of general education courses in consultation with an adviser.</td>
<td>30</td>
<td></td>
</tr>
</tbody>
</table>

Major requirements

• Major core requirements

<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; PHYS 320</td>
<td>4</td>
</tr>
<tr>
<td>SPACE 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>
<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>
</tbody>
</table>

• Major electives

Select a total of nine credits from the list of elective physics and physics-related courses provided below. Those students who have their primary major in physics are required to fulfill at least three of these credits using upper-level physics courses.

Ancillary requirements

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>HUMS 202</td>
<td>Choices in a Consumer Society</td>
<td>1</td>
</tr>
<tr>
<td>MATH 200</td>
<td>Calculus with Analytic Geometry I</td>
<td>4</td>
</tr>
<tr>
<td>MATH 201</td>
<td>Calculus with Analytic Geometry II</td>
<td>4</td>
</tr>
<tr>
<td>MATH 301</td>
<td>Differential Equations</td>
<td>3</td>
</tr>
<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>
<td>5</td>
</tr>
</tbody>
</table>

Experiential fine arts

| Select any course. | 35-43 |

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

1-6

Open electives

| Select any course. | 35-43 |

Total Hours

120

Course offered by the School of the Arts

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

Physics and physics-related electives

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS 211</td>
<td>Physical Analysis</td>
<td></td>
</tr>
<tr>
<td>PHYS 302</td>
<td>Classical Mechanics II</td>
<td></td>
</tr>
<tr>
<td>PHYS 325</td>
<td>Visualization of Physics Using Mathematica</td>
<td></td>
</tr>
<tr>
<td>PHYS 335</td>
<td>Experimental Skills for Physicists</td>
<td></td>
</tr>
<tr>
<td>PHYS 351</td>
<td>Guided Inquiry for University Physics I</td>
<td></td>
</tr>
<tr>
<td>PHYS 352</td>
<td>Guided Inquiry for University Physics II</td>
<td></td>
</tr>
<tr>
<td>PHYS 377</td>
<td>Electromagnetism II</td>
<td></td>
</tr>
<tr>
<td>PHYS 397</td>
<td>Directed Study (maximum of 3 credits)</td>
<td></td>
</tr>
<tr>
<td>PHYS 417</td>
<td>Topics in Biophysics</td>
<td></td>
</tr>
<tr>
<td>PHYS 420</td>
<td>Quantum Physics II</td>
<td></td>
</tr>
<tr>
<td>PHYS 422</td>
<td>Optics</td>
<td></td>
</tr>
<tr>
<td>PHYS 425</td>
<td>Computational Physics and Data Analysis</td>
<td></td>
</tr>
<tr>
<td>PHYS 440</td>
<td>Introduction to Condensed Matter Physics</td>
<td></td>
</tr>
<tr>
<td>PHYS 470</td>
<td>Introduction to Nanoscience</td>
<td></td>
</tr>
<tr>
<td>PHYS 480</td>
<td>Particle Physics</td>
<td></td>
</tr>
<tr>
<td>PHYS 483</td>
<td>Introduction to Astrophysics</td>
<td></td>
</tr>
<tr>
<td>PHYS 491</td>
<td>Topics in Physics (maximum of 3 credits)</td>
<td></td>
</tr>
<tr>
<td>PHYS 492</td>
<td>Independent Study (maximum of 3 credits)</td>
<td></td>
</tr>
</tbody>
</table>
PHYS 514  Modeling Biocomplexity
PHYS 522  Optics and Laser Physics
PHYS 571  Theoretical Mechanics
PHYS 573  Analytical Methods in Physics
PHYS 576  Electromagnetic Theory
PHYS 580  Quantum Mechanics
PHYS 583  Geometrical Methods of Physics and Gravitation

Any of the following math or statistics courses:
MATH 310  Linear Algebra
MATH 415  Numerical Methods
MATH 433  Partial Differential Equations
MATH 511  Applied Linear Algebra
STAT 441  Applied Statistics for Engineers and Scientists

Any of the following chemistry courses:
CHEM 409  Instrumental Analysis
CHEM 510  Atomic and Molecular Structure

Any of the following engineering courses:
CLSE 301  Transport Phenomena I
CLSE 302  Transport Phenomena II
EGMN 301  Fluid Mechanics
EGMN 309  Material Science for Engineers
EGMN 351  Nuclear Engineering Fundamentals
EGMN 352  Nuclear Reactor Theory
EGRB 427  Biomaterials
EGRE 303  Electronic Devices
EGRE 306  Introduction to Microelectronics
EGRE 307  Integrated Circuits
EGRE 310  Electromagnetic Fields and Waves
EGRE 334  Introduction to Microfabrication
EGRE 521  Advanced Semiconductor Devices

Those interested in experimental physics should also take one or more credits in PHYS 397 or PHYS 492.

Courses not applicable toward the major

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS 302</td>
<td>Classical Mechanics II</td>
<td></td>
</tr>
<tr>
<td>PHYS 325</td>
<td>Visualization of Physics Using Mathematica</td>
<td></td>
</tr>
<tr>
<td>PHYS 420</td>
<td>Quantum Physics II</td>
<td></td>
</tr>
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<td>PHYS 483</td>
<td>Introduction to Astrophysics</td>
<td></td>
</tr>
<tr>
<td>PHYS 514</td>
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<td></td>
</tr>
<tr>
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<td></td>
</tr>
<tr>
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<td>PHYS 576</td>
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<td></td>
</tr>
<tr>
<td>PHYS 580</td>
<td>Quantum Mechanics</td>
<td></td>
</tr>
<tr>
<td>PHYS 583</td>
<td>Geometrical Methods of Physics and Gravitation</td>
<td></td>
</tr>
</tbody>
</table>

Those students intending to pursue graduate studies in physics should choose electives from the following:

Those interested in experimental physics should also take one or more credits in PHYS 397 or PHYS 492.

Courses not applicable toward the major

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS 101</td>
<td>Foundations of Physics</td>
<td></td>
</tr>
<tr>
<td>PHYS 103</td>
<td>Elementary Astronomy</td>
<td></td>
</tr>
<tr>
<td>PHYS 107</td>
<td>Wonders of Technology</td>
<td></td>
</tr>
<tr>
<td>PHYS 201</td>
<td>General Physics I</td>
<td></td>
</tr>
<tr>
<td>PHYS 202</td>
<td>General Physics II</td>
<td></td>
</tr>
<tr>
<td>PHYS 215</td>
<td>Science, Technology and Society</td>
<td></td>
</tr>
<tr>
<td>PHYS 291</td>
<td>Topics in Physical Science</td>
<td></td>
</tr>
<tr>
<td>PHYS/MHIS 307</td>
<td>The Physics of Sound and Music</td>
<td></td>
</tr>
<tr>
<td>PHYS/ENVS 315</td>
<td>Energy and the Environment</td>
<td></td>
</tr>
<tr>
<td>PHYS 391</td>
<td>Topics in Physics</td>
<td></td>
</tr>
<tr>
<td>PHYZ 101</td>
<td>Foundations of Physics Laboratory</td>
<td></td>
</tr>
<tr>
<td>PHYZ 103</td>
<td>Elementary Astronomy Laboratory</td>
<td></td>
</tr>
</tbody>
</table>

What follows is a sample plan that meets the prescribed requirements within a four-year course of study at VCU. Please contact your adviser before beginning course work toward a degree.

Freshman year

Fall semester

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 200</td>
<td>Calculus with Analytic Geometry I</td>
<td>4</td>
</tr>
<tr>
<td>UNIV 111</td>
<td>Focused Inquiry I</td>
<td>3</td>
</tr>
<tr>
<td>General education course (select AOI for global perspectives)</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

Spring semester

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>HUMS 202</td>
<td>Choices in a Consumer Society</td>
<td>1</td>
</tr>
<tr>
<td>MATH 201</td>
<td>Calculus with Analytic Geometry II</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>
<td>5</td>
</tr>
<tr>
<td>UNIV 112</td>
<td>Focused Inquiry II</td>
<td>3</td>
</tr>
<tr>
<td>General education course (select BOK to complete breadth of knowledge requirement and AOI for creativity, innovation and aesthetic inquiry)</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

Sophomore year
Students holding these degrees will be more competitive when seeking research and development positions in industry and admission to physics Ph.D. programs. In addition, an M.S. degree is required for most undergraduate teaching positions. The master's program enables students to deepen their understanding of physics while gaining actual experience in research at the frontiers of physics.

**Entrance to the accelerated program**

Interested undergraduate students should consult with their adviser as early as possible to receive specific information about the accelerated program, determine academic eligibility and submit (no later than two semesters prior to graduating with a baccalaureate degree, that is, before the end of the spring semester of their junior year) an Accelerated Program Declaration Form to be approved by the graduate program director. Limited spaces may be available in the accelerated program. Academically qualified students may not receive approval if capacity has been reached.

Minimum qualifications for entrance to this accelerated program include completion of 85 undergraduate credit hours, including PHYS 376 and PHYS 380; an overall GPA of 3.25; and a GPA of 3.25 in physics course work.

Once enrolled in the accelerated program, students must meet the standards of performance applicable to graduate students as described in the “Satisfactory academic progress” section of Bulletin, including maintaining a 3.0 GPA. Guidance to students in an accelerated program is provided by both the undergraduate physics adviser and the graduate adviser specified in the student’s agreed-upon plan of study.

**Admission to the graduate program**

Entrance to the accelerated program enables the student to take the approved shared courses that will apply to the undergraduate and graduate degrees. However, entry into an accelerated program via an approved Accelerated Program Declaration Form does not constitute application or admission into the graduate program. Admission to the graduate program requires a separate step that occurs through a formal application. In order to continue pursuing the master’s degree after the baccalaureate degree is conferred, accelerated students must follow the admission to graduate study requirements outlined in the VCU Bulletin.

**Degree requirements**

The Bachelor of Science in Physics degree will be awarded upon completion of a minimum of 120 credits and the satisfactory completion of all undergraduate degree requirements as stated in the Undergraduate Bulletin.

A maximum of 12 graduate credits may be taken prior to completion of the baccalaureate degree. These graduate credits substitute for required major electives or open elective credits for the undergraduate degree. These courses are shared credits with the graduate program, meaning that they will be applied to both undergraduate and graduate degree requirements.

The graduate physics courses that may be taken as an undergraduate, once a student is admitted to the program, are:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>NANO 570</td>
<td>Nanoscale Physics</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 560</td>
<td>Fundamentals of Semiconductor Nanostructures</td>
<td>3</td>
</tr>
</tbody>
</table>
# Recommended course sequence/plan of study

What follows is the recommended plan of study for students interested in the accelerated program beginning in the fall of the junior year prior to admission to the accelerated program in the senior year. The thesis option for the M.S. is shown.

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Junior year</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall semester</td>
<td></td>
<td></td>
</tr>
<tr>
<td>General education course (select BOK to complete breadth of knowledge requirement)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Major electives</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Open electives</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Term Hours:</td>
<td></td>
<td>15</td>
</tr>
<tr>
<td>Spring semester</td>
<td></td>
<td></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>
<td>3</td>
</tr>
<tr>
<td>Open electives</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Term Hours:</td>
<td></td>
<td>15</td>
</tr>
<tr>
<td><strong>Senior year</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall semester</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NANO 570</td>
<td>Nanoscale Physics</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 450</td>
<td>Senior Physics Laboratory</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 571</td>
<td>Theoretical Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>Electives</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Term Hours:</td>
<td></td>
<td>15</td>
</tr>
<tr>
<td>Spring semester</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PHYS 490</td>
<td>Seminar in Conceptual Physics</td>
<td>1</td>
</tr>
<tr>
<td>PHYS 492</td>
<td>Independent Study (begin research)</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 560</td>
<td>Fundamentals of Semiconductor Nanostructures</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 580</td>
<td>Quantum Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>Open electives</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Term Hours:</td>
<td></td>
<td>16</td>
</tr>
<tr>
<td><strong>Fifth year</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall semester</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NANO 571</td>
<td>Nanoscale Chemistry</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 697</td>
<td>Directed Research</td>
<td>3</td>
</tr>
<tr>
<td>600-level PHYS elective</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Term Hours:</td>
<td></td>
<td>9</td>
</tr>
<tr>
<td>Spring semester</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PHYS 697</td>
<td>Directed Research</td>
<td>6</td>
</tr>
<tr>
<td>600-level PHYS elective</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Term Hours:</td>
<td></td>
<td>9</td>
</tr>
</tbody>
</table>

It is recommended, but not required, that one hour of PHYS 690 be taken as part of the elective credits.