PHYSICS, BACHELOR OF SCIENCE (B.S.) WITH A CONCENTRATION IN NANOSCIENCE

The Bachelor of Science in Physics with a concentration in nanoscience requires a minimum of 120 credits. The curriculum prepares students for careers in industry, academia, applied health or nanoscience-related areas. The curriculum also prepares students for graduate studies in nanoscience and related areas.

Student learning outcomes

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

Physics core outcomes

- Perform scientific reasoning and complex problem-solving
- 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

Nanoscience concentration-specific outcome

- Demonstrate a fundamental understanding of the novel phenomena of matter that occur at the size scale of nanometers

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 40-42 credits in physics and physics-related electives and 26-34 credits in ancillary requirements.

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

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 101</td>
<td>General Chemistry I (satisfies general education AOI for scientific and logical reasoning)</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 102 &amp; CHEZ 102</td>
<td>General Chemistry II and General Chemistry Laboratory II (four credits)</td>
<td>6</td>
</tr>
<tr>
<td>EGRE 334</td>
<td>Introduction to Microfabrication (four credits)</td>
<td>4</td>
</tr>
<tr>
<td>NANO 570</td>
<td>Nanoscale Physics (three credits)</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 377</td>
<td>Electromagnetism II (three credits)</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 522</td>
<td>Optics and Laser Physics (three credits)</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 560</td>
<td>Fundamentals of Semiconductor Nanostructures (three credits)</td>
<td>3</td>
</tr>
<tr>
<td>MATH 200</td>
<td>Calculus with Analytic Geometry I (satisfies general education quantitative foundations)</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 (satisfies general education BOK for natural sciences and AOI for scientific and logical reasoning)</td>
<td>5</td>
</tr>
</tbody>
</table>

Experiential fine arts 1 1-3

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

Open electives

Select any course. 26-36

Total Hours 120

1

Course offered by the School of the Arts

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

The following courses are not applicable toward the physics major requirements but may be used as general electives toward the bachelor’s degree:

- MATH 307 Multivariate Calculus
- PHYS 208 University Physics II
- UNIV 200 Advanced Focused Inquiry: Literacies, Research and Communication
- Foreign language 101

Term Hours: 15

Spring semester

- MATH 301 Differential Equations
- PHYS 301 Classical Mechanics I
- PHYS 320 Modern Physics
- & PHYS 320 and Modern Physics Laboratory
- Foreign language 102

Term Hours: 13

Junior year

Fall semester

- PHYS 376 Electromagnetism I
- PHYS 380 Quantum Physics I
- General education course (select BOK to complete breadth of knowledge requirement AOI for creativity, innovation and aesthetic inquiry)
- Open electives

Term Hours: 15-16

Spring semester

- PHYS 335 Experimental Skills for Physicists
- PHYS 340 Statistical Mechanics and Thermodynamics
- Open electives

Term Hours: 15

Senior year

Fall semester

- PHYS 397 Directed Study
- PHYS 440 Introduction to Condensed Matter Physics
- PHYS 450 Senior Physics Laboratory
- PHYS 470 Introduction to Nanoscience
- Concentration elective

Term Hours: 15-16

Spring semester

- PHYS 490 Seminar in Conceptual Physics
- PHYS 492 Independent Study (with NANO adviser)
- Concentration elective
- Open elective (complete upper-level if needed)

Term Hours: 16-17

Total Hours: 120-125

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

Accelerated B.S. and M.S.

The accelerated B.S. and M.S. program allows academically talented students to earn both the B.S. in Physics and M.S. in Physics and Applied Physics in a minimum of five years by completing approved graduate courses during the senior year of their undergraduate program. Students in the program may count up to 12 hours of graduate courses toward both the B.S. and M.S. degrees. Thus, the two degrees may be earned...
Physics, Bachelor of Science (B.S.) with a concentration in nanoscience

with a minimum of 138 credits rather than the 150 credits necessary if the two degrees are pursued separately.

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>
<tr>
<td>PHYS 571</td>
<td>Theoretical Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 580</td>
<td>Quantum Mechanics</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.

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<thead>
<tr>
<th>Course</th>
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<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>Fall</td>
<td>General education course (select BOK to complete breadth of knowledge requirement)</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</td>
<td>Statistical Mechanics and Therodynamics</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 340</td>
<td></td>
<td></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>
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<tr>
<td>Open electives</td>
<td></td>
<td>6</td>
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<tr>
<td>Term Hours:</td>
<td></td>
<td>15</td>
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<tr>
<td>Senior year</td>
<td></td>
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</tr>
<tr>
<td>Fall</td>
<td>Seminar in Conceptual Physics</td>
<td>1</td>
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<tr>
<td>PHYS 490</td>
<td></td>
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<tr>
<td>PHYS 492</td>
<td>Independent Study (begin research)</td>
<td>3</td>
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<tr>
<td>Electives</td>
<td></td>
<td>6</td>
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<tr>
<td>Term Hours:</td>
<td></td>
<td>15</td>
</tr>
<tr>
<td>Spring</td>
<td>Fundamentals of Semiconductor Nanostructures</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 560</td>
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<tr>
<td>PHYS 580</td>
<td>Quantum Mechanics</td>
<td>3</td>
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<tr>
<td>Open electives</td>
<td></td>
<td>6</td>
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<tr>
<td>Term Hours:</td>
<td></td>
<td>16</td>
</tr>
<tr>
<td>Fifth year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall</td>
<td>Nanoscale Chemistry</td>
<td>3</td>
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<tr>
<td>PHYS 571</td>
<td></td>
<td></td>
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<tr>
<td>PHYS 697</td>
<td>Directed Research</td>
<td>3</td>
</tr>
<tr>
<td>Electives</td>
<td></td>
<td>6</td>
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<tr>
<td>Term Hours:</td>
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<tr>
<td>Spring</td>
<td>Directed Research</td>
<td>6</td>
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<tr>
<td>PHYS 697</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electives</td>
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<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.