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 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

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 (https://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

Course	Title	Hours
General education (https://bulletin.vcu.edu/undergraduate/undergraduate-study/general-education-curriculum/)		
Select 30 credits of general education courses in consultation with an adviser.		30
Major requirements		
• Major core requirements		
PHYS 208	University Physics II	5
PHYS 301	Classical Mechanics I	3
PHYS 320 & PHYZ 320	Modern Physics and Modern Physics Laboratory	4
PHYS 340	Statistical Mechanics and Thermodynamics	3
PHYS 376	Electromagnetism I	3
PHYS 380	Quantum Physics I	3
PHYS 450	Senior Physics Laboratory	3
PHYS 490	Seminar in Conceptual Physics	1
• Concentration requirements		
PHYS 335	Experimental Skills for Physicists	3
PHYS 470	Introduction to Nanoscience	3
PHYS 492	Independent Study (with NANO faculty)	3
Concentration electives		
Select two from:		6-8
CHEM 102 & CHEZ 102	General Chemistry II and General Chemistry Laboratory II (four credits)	
EGRE 334	Introduction to Microfabrication (four credits)	
NANO 570	Nanoscale Physics (three credits)	
PHYS 377	Electromagnetism II (three credits)	
PHYS 522	Optics and Laser Physics (three credits)	
PHYS 560	Fundamentals of Semiconductor Nanostructures (three credits)	
Ancillary requirements		
CHEM 101	General Chemistry I (satisfies general education AOI for scientific and logical reasoning)	3
CHEZ 101	General Chemistry Laboratory I	1
HUMS 202	Choices in a Consumer Society	1
MATH 200	Calculus with Analytic Geometry I (satisfies general education quantitative foundations)	4
MATH 201	Calculus with Analytic Geometry II	4
MATH 301	Differential Equations	3
MATH 307	Multivariate Calculus	4
PHYS 207	University Physics I (satisfies general education BOK for natural sciences and AOI for scientific and logical reasoning)	5
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

Course	Title	Hours
The following courses are not applicable toward the physics major requirements but may be used as general electives toward the bachelor's degree:		
PHYS 101	Foundations of Physics	
PHYS 103	Elementary Astronomy	
PHYS 107	Wonders of Technology	
PHYS 201	General Physics I	
PHYS 202	General Physics II	
PHYS 215	Science, Technology and Society	
PHYS 291	Topics in Physical Science	
PHYS/MHIS 307	The Physics of Sound and Music	
PHYS/ENVS 315	Energy and the Environment	
PHYS 391	Topics in Physics	
PHYZ 101	Foundations of Physics Laboratory	
PHYZ 103	Elementary Astronomy Laboratory	

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		**Hours**
CHEM 101	General Chemistry I (satisfies general education AOI for scientific and logical reasoning)	3
CHEZ 101	General Chemistry Laboratory I	1
MATH 200	Calculus with Analytic Geometry I (satisfies general education quantitative foundations)	4
UNIV 111 Play course video for Introduction to Focused Inquiry: Investigation and Communicatio	Introduction to Focused Inquiry: Investigation and Communication (satisfies general education UNIV foundations)	3
Experiential fine arts		1-3
General education course		3
	Term Hours:	**15-17**
Spring semester		
HUMS 202	Choices in a Consumer Society	1
MATH 201	Calculus with Analytic Geometry II	4
PHYS 207	University Physics I (satisfies general education BOK for natural sciences and AOI for scientific and logical reasoning)	5
UNIV 112 Play course video for Focused Inquiry II	Focused Inquiry II (satisfies general education UNIV foundations)	3
General education course (select BOK to complete breadth of knowledge requirement and AOI for diversities in the human experience)		3
	Term Hours:	**16**
Sophomore year		
Fall semester		
MATH 307	Multivariate Calculus	4
PHYS 208	University Physics II	5
UNIV 200	Advanced Focused Inquiry: Literacies, Research and Communication (satisfies general education UNIV foundations)	3
Foreign language 101		3
	Term Hours:	**15**
Spring semester		
MATH 301	Differential Equations	3
PHYS 301	Classical Mechanics I	3
PHYS 320 & PHYZ 320	Modern Physics and Modern Physics Laboratory	4
Foreign language 102		3
	Term Hours:	**13**
Junior year		
Fall semester		
PHYS 376	Electromagnetism I	3
PHYS 380	Quantum Physics I	3
General education course (select BOK to complete breadth of knowledge requirement AOI for creativity, innovation and aesthetic inquiry)		3
Open electives		6-7
	Term Hours:	**15-16**
Spring semester		
PHYS 335	Experimental Skills for Physicists	3
PHYS 340	Statistical Mechanics and Thermodynamics	3
Open electives		9
	Term Hours:	**15**
Senior year		
Fall semester		
PHYS 397	Directed Study	3
PHYS 440	Introduction to Condensed Matter Physics	3
PHYS 450	Senior Physics Laboratory	3
PHYS 470	Introduction to Nanoscience	3
Concentration elective		3-4
	Term Hours:	**15-16**
Spring semester		
PHYS 490	Seminar in Conceptual Physics	1
PHYS 492	Independent Study (with NANO adviser)	3
Concentration elective		3-4
Open elective (complete upper-level if needed)		9
	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 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:

Course	Title	Hours
NANO 530	Nanomaterials Characterization Techniques	3
NANO 570	Nanoscale Physics	3
NANO 571	Nanoscale Chemistry	3
PHYS 522	Optics and Laser Physics	3
PHYS 560	Fundamentals of Semiconductor Nanostructures	3

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.

Course	Title	Hours
Junior year		
Fall semester		
General education course (select BOK to complete breadth of knowledge requirement		3
Major electives		6
Open electives		6
Term Hours:		15
Spring semester		
PHYS 340	Statistical Mechanics and Thermodynamics	3
PHYS 376	Electromagnetism I	3
PHYS 380	Quantum Physics I	3
Open electives		6
Term Hours:		15
Senior year		
Fall semester		
NANO 570	Nanoscale Physics	3
PHYS 450	Senior Physics Laboratory	3
Electives		6
PHYS 560	Fundamentals of Semiconductor Nanostructures	3
Term Hours:		15
Spring semester		
NANO 530	Nanomaterials Characterization Techniques	3
PHYS 490	Seminar in Conceptual Physics	1
PHYS 492	Independent Study (begin research)	3
PHYS 522	Optics and Laser Physics	3
Open electives		6
Term Hours:		16
Fifth year		
Fall semester		
PHYS 697	Directed Research	5

600-level PHYS elective [1]		4
Term Hours:		9
Spring semester		
NANO 571	Nanoscale Chemistry	3
PHYS 697	Directed Research	5
600-level PHYS elective [1]		1
Term Hours:		9

1

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