MATHEMATICAL SCIENCES, BACHELOR OF SCIENCE (B.S.) WITH A CONCENTRATION IN BIOMATHEMATICS

The curriculum in mathematical sciences promotes understanding of the mathematical sciences and their structures, uses and relationships to other disciplines. To this end, the scholarly growth of the faculty and students in the mathematical sciences is nurtured through study, research and a high standard of teaching. The curriculum provides a sound foundation for the student seeking to enter a career with a technological orientation or for the student who wishes to pursue graduate study in applied mathematics, biomathematics, mathematics, operations research, statistics, teaching mathematics in secondary schools or related fields.

A Bachelor of Science is offered jointly by the Department of Mathematics and Applied Mathematics and the Department of Statistical Sciences and Operations Research. In the Department of Mathematics and Applied Mathematics, students pursuing the Bachelor of Science in Mathematical Sciences can choose a concentration of biomathematics, which focuses on the overlap between mathematics and the disciplines of biology and medicine. This concentration covers the mathematical methods of modeling and analysis of phenomena in the life sciences.

Student learning outcomes

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

Bachelor of Science in Mathematical Sciences core outcomes

- Solve mathematical problems
- Solve and interpret mathematical problems which originate from applications outside of mathematics
- Use technology to solve and/or explore mathematics problems

Biomathematics concentration-specific outcome

- Write mathematics (not including mathematical proofs) clearly, concisely and correctly
- Write mathematical proofs clearly, concisely and correctly
- Read and comprehend mathematical works
- Collaborate in projects
- Make effective presentations to demonstrate their understanding of mathematical ideas
- Write prose about mathematics
- Use appropriate mathematical methods to investigate mathematical models for problems in the biological sciences

Special requirements

The B.S. in Mathematical Sciences requires a minimum of 120 credits. Along with the general education requirements of the College of Humanities and Sciences and the undergraduate degree requirements, students are required to take core courses and fulfill specific requirements for the degree.

Based on the results of the Mathematics Placement Test, students may be required to take MATH 151. No more than one course in mathematics (MATH) at the 100 level can count for the general requirements toward the degree. Credit for 100-level mathematical sciences courses cannot be applied toward the mathematical sciences courses required for the major in mathematical sciences.

Double major

Students who meet the requirements for two of the concentrations within the mathematical sciences curriculum can receive a double major. To initiate a double major, students must obtain the appropriate form from the Office of Records and Registration.

Second baccalaureate degree

For students possessing a bachelor's degree and wishing to gain undergraduate preparation in an area of mathematical sciences, second baccalaureate degrees are offered through the department. For detailed information about these programs, refer to the "Academic regulations and general degree requirement" section of this bulletin.

Degree requirements for Mathematical Sciences, Bachelor of Science (B.S.) with a concentration in biomathematics

Course	Title	Hours
General education (http://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		
MATH 201	Calculus with Analytic Geometry II [1]	4
MATH 307	Multivariate Calculus [1]	4
MATH 310	Linear Algebra [1]	3
• Additional major requirements		
MATH 255	Introduction to Computational Mathematics	3
or CMSC 245	Introduction to Programming Using C++	
or EGRE 245	Engineering Programming	
MATH 300	Introduction to Mathematical Reasoning [1]	3
MATH 407	Real Analysis	3
MATH 490	Mathematical Expositions	3
• Concentration requirements		
MATH 301	Differential Equations [1]	3
MATH 380	Introduction to Mathematical Biology	4
MATH 432	Ordinary Differential Equations	3
or MATH 433	Partial Differential Equations	
or MATH 434	Discrete Dynamical Systems	
MATH 435	Mathematical and Computational Modeling	3
MATH 585	Biomathematics Seminar:____	2
Concentration electives [2]		0-6
Ancillary requirements		
HUMS 202	Choices in a Consumer Society	1

MATH 200	Calculus with Analytic Geometry I (satisfies general education quantitative foundations) [1]	4
STAT 212	Concepts of Statistics	3
Experiential fine arts [3]		1-3
Foreign language through the 102 level (by course or placement)		0-6
Natural science sequence: Select one sequence from list below (satisfies general education BOK for natural sciences and AOI for scientific and logical reasoning)		8-10
Natural science elective (different from chosen science sequence)		3-5
Open electives		
Select any course.		21-40
Total Hours		**120**

[1] These courses/credits require a minimum grade of C.

[2] Six additional upper-level credits in the mathematical sciences (MATH, STAT, OPER, CMSC) or the completion of a minor or a double major.

[3] Course offered by the School of the Arts

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

Natural science sequence

Course	Title	Hours
Select one of the following sequences:		8-10
Sequence 1		
BIOL 151	Introduction to Biological Sciences I (satisfies general education BOK for natural sciences and AOI for scientific and logical reasoning)	3
BIOZ 151	Introduction to Biological Science Laboratory I	1
BIOL 152	Introduction to Biological Sciences II	3
BIOZ 152	Introduction to Biological Science Laboratory II	1
Sequence 2		
CHEM 101	General Chemistry I (satisfies general education BOK for natural sciences and AOI for scientific and logical reasoning)	3
CHEZ 101	General Chemistry Laboratory I (satisfies general education AOI for scientific and logical reasoning)	1
CHEM 102	General Chemistry II	3
CHEZ 102	General Chemistry Laboratory II	1
Sequence 3		
PHYS 201	General Physics I (satisfies general education BOK for natural sciences and AOI for scientific and logical reasoning)	4
PHYS 202	General Physics II	4
Sequence 4		
PHYS 207	University Physics I (satisfies general education BOK for natural sciences and AOI for scientific and logical reasoning)	5
PHYS 208	University Physics II	5

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**
MATH 200	Calculus with Analytic Geometry I (satisfies general education quantitative foundations)	4
UNIV 101	Introduction to the University	1
UNIV 111 Play course video for Focused Inquiry I	Focused Inquiry I (satisfies general education UNIV foundations)	3
General education course (select AOI in consultation with adviser)		3
General education course		3
	Term Hours:	**14**
Spring semester		
HUMS 202	Choices in a Consumer Society	1
MATH 201	Calculus with Analytic Geometry II	4
STAT 212	Concepts of Statistics	3
UNIV 112 Play course video for Focused Inquiry II	Focused Inquiry II (satisfies general education UNIV foundations)	3
Experiential fine arts		1-3
General education course (select AOI in consultation with adviser)		3
	Term Hours:	**15-17**
Sophomore year		
Fall semester		
MATH 255	Introduction to Computational Mathematics	3
MATH 300	Introduction to Mathematical Reasoning	3
MATH 307	Multivariate Calculus	4
UNIV 200	Advanced Focused Inquiry: Literacies, Research and Communication (satisfies general education UNIV foundations)	3
Foreign language 101		3
	Term Hours:	**16**
Spring semester		
MATH 301	Differential Equations	3
MATH 310	Linear Algebra	3
Foreign language 102		3
General education course (select BOK to complete breadth of knowledge requirement)		3

General education course (select BOK to complete breadth of knowledge requirement)		3
	Term Hours:	**15**
Junior year		
Fall semester		
MATH 380	Introduction to Mathematical Biology	4
Natural sciences sequence (select one of the following) (satisfies general education BOK for natural sciences and AOI for scientific and logical reasoning)		4-5
BIOL 151 & BIOZ 151	Introduction to Biological Sciences I and Introduction to Biological Science Laboratory I	-
CHEM 101 & CHEZ 101	General Chemistry I and General Chemistry Laboratory I	-
PHYS 201	General Physics I	-
PHYS 207	University Physics I	-
Open electives		6
	Term Hours:	**14-15**
Spring semester		
MATH 432 or MATH 433 or MATH 434	Ordinary Differential Equations or Partial Differential Equations or Discrete Dynamical Systems	3
Concentration elective (upper level)		3
Natural sciences sequence (Select one of the following with appropriate matching course.)		4-5
BIOL 152 & BIOZ 152	Introduction to Biological Sciences II and Introduction to Biological Science Laboratory II	-
CHEM 102 & CHEZ 102	General Chemistry II and General Chemistry Laboratory II	-
PHYS 202	General Physics II	-
PHYS 208	University Physics II	-
Open electives		6
	Term Hours:	**16-17**
Senior year		
Fall semester		
MATH 407	Real Analysis	3
MATH 435	Mathematical and Computational Modeling	3
MATH 585	Biomathematics Seminar:____	1
Natural sciences elective [1]		3-5
Open electives		6
	Term Hours:	**16-18**
Spring semester		
MATH 490	Mathematical Expositions	3
MATH 585	Biomathematics Seminar:____	1
Concentration elective (upper-level)		3
Open electives		7-9
	Term Hours:	**14-16**
	Total Hours:	**120-128**

1 Different science than chosen for sequence.

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 qualified students in the applied mathematics and biomathematics concentrations to earn both the B.S. in Mathematical Sciences and the M.S. in Mathematical Sciences with a concentration in applied mathematics 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 are better prepared for a career in a technical industry, for a career in teaching and/or for further studies in a quantitative Ph.D. program, such as mathematics, data sciences or statistics. An accelerated B.S. and M.S. degree in Mathematics offers a direct pathway toward high-paying positions in big tech companies and financial institutions. Over the past decade, the increasingly competitive application process for Ph.D. programs in mathematics has made it extremely difficult for students holding only a B.S. degree to be admitted. On the other hand, students graduating from VCU with a master's in mathematical sciences have a history of getting into highly rated Ph.D. programs, often with generous funding.

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 90 undergraduate credit hours, including STAT 212, MATH 255, MATH 301, MATH 307, MATH 310, MATH 380 (this course for the biomathematics concentration only) and MATH 407; an overall GPA of 3.0; and a GPA of 3.0 in mathematics course work. Students who do not meet the minimum GPA requirements may submit general GRE scores to receive further consideration. Students who are interested in the accelerated program should consult with the faculty adviser to the Mathematical Sciences M.S. program before they have completed 90 credits. Successful applicants would enter the program in the fall semester of their senior year.

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 the Graduate Bulletin, including maintaining a 3.0 GPA. Guidance to students admitted to the accelerated program is provided by both the undergraduate mathematics adviser and the faculty adviser to the graduate program.

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 to the master's program, which is submitted through Graduate Admissions no later than a semester prior to graduation with the baccalaureate degree, that is, before the end of the fall semester of the senior year. 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. One of the three required reference letters must come from a Department of Mathematics and Applied Mathematics faculty member.

Degree requirements

The Bachelor of Science in Mathematical Sciences degree (with a concentration in either applied mathematics or biomathematics) will be awarded upon completion of a minimum of 120 credits in undergraduate program credits and the satisfactory completion of all undergraduate degree requirements as stated in the Undergraduate Bulletin.

Students must pass a comprehensive exam in the core courses and selected elective courses determined by the Department of Mathematics and Applied Mathematics.

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

The graduate mathematics courses that may be taken as an undergraduate once a student is admitted to the program are below.

Course	Title	Hours
MATH 507	Bridge to Modern Analysis (may count as undergraduate major elective)	3
MATH 515	Numerical Analysis (may count as undergraduate major requirement or open elective)	3
MATH 535	Introduction to Dynamical Systems (may count as undergraduate major elective)	3
MATH 610	Advanced Linear Algebra	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.

Course	Title	Hours
Junior year		
Fall semester		
MATH 407	Real Analysis	3
MATH 432	Ordinary Differential Equations	3
Experiential fine arts		1-3
General education course		3
Natural science sequence		4-5
Term Hours:		14-17
Spring semester		
MATH 433	Partial Differential Equations	3
MATH 435	Mathematical and Computational Modeling	3
General education course		3
Natural science sequence		4-5
Open elective		3
Term Hours:		16-17
Senior year		
Fall semester		
MATH 507	Bridge to Modern Analysis	3
MATH 535	Introduction to Dynamical Systems	3
MATH 585	Biomathematics Seminar:____ (biomathematics concentration only)	1
MATH 610	Advanced Linear Algebra	3
Natural science elective		3-5
Open electives		3
Term Hours:		16-18
Spring semester		
MATH 490	Mathematical Expositions	3
MATH 515	Numerical Analysis	3
Concentration elective (appropriate to applied mathematics or biomathematics)		3
Open electives		6
Term Hours:		15
Fifth year		
Fall semester		
MATH 615	Iterative Numerical Methods	3
MATH 769	Topics in Applied Mathematics: ____	3
Graduate math elective		3
Term Hours:		9
Spring semester		
MATH 632	Ordinary Differential Equations I	3
or MATH 633	Partial Differential Equations	
MATH 690	Research Seminar	2
Math electives (600- to 700-level)		6
Term Hours:		11