MATHEMATICAL SCIENCES,
MASTER OF SCIENCE (M.S.)
WITH A CONCENTRATION IN
OPERATIONS RESEARCH

Program goal
The Department of Mathematics and Applied Mathematics and the Department of Statistical Sciences and Operations Research jointly offer the M.S. in Mathematical Sciences.

The mission of the Department of Statistical Sciences and Operations Research is to offer a strong undergraduate and graduate education, with an increasing focus on the development of cross-disciplinary efforts that will prepare students for real-world applications and stimulating employment and career opportunities.

The program offers maximum flexibility by allowing students, in consultation with their graduate committees, to design a course of study that will best develop competence in those areas most relevant to their scholarly and professional objectives. Students may obtain a designation on their transcripts indicating that their graduate study has emphasized the mathematics concentration by completing the requirements that are listed here. A student who has not satisfied the requirements for one of the program concentrations offered, but who has otherwise fulfilled all the requirements for a master's degree, will be awarded a degree of Master of Science in Mathematical Sciences without any specialization.

Student learning outcomes
1. Students will demonstrate a comprehensive understanding of basic mathematical programming methods, stochastic models and decision analysis.
2. Students will be able to obtain, analyze and interpret the data necessary to perform operations research projects.
3. Students will be able to solve a wide variety of operations research problems using the software commonly used in industry.
4. Students will know how to clearly and concisely present technical information in writing and through oral presentations.

VCU Graduate Bulletin, VCU Graduate School and general academic policies and regulations for all graduate students in all graduate programs
The VCU Graduate Bulletin website documents the official admission and academic rules and regulations that govern graduate education for all graduate programs at the university. These policies are established by the graduate faculty of the university through their elected representatives to the University Graduate Council.

It is the responsibility of all graduate students, both on- and off-campus, to be familiar with the VCU Graduate Bulletin as well as the Graduate School website (http://www.vcu.edu/graduate) and academic regulations in individual school and department publications and on program websites. However, in all cases, the official policies and procedures of the University Graduate Council, as published on the VCU Graduate Bulletin and Graduate School websites, take precedence over individual program policies and guidelines.

Visit the academic regulations section for additional information on academic regulations for graduate students. (http://bulletin.vcu.edu/academic-regs)

Degree candidacy requirements
A graduate student admitted to a program or concentration requiring a final research project, work of art, thesis or dissertation, must qualify for continuing master’s or doctoral status according to the degree candidacy requirements of the student’s graduate program. Admission to degree candidacy, if applicable, is a formal statement by the graduate student’s faculty regarding the student’s academic achievements and the student’s readiness to proceed to the final research phase of the degree program.

Graduate students and program directors should refer to the following degree candidacy policy as published in the VCU Graduate Bulletin for complete information and instructions.

Visit the academic regulations section for additional information on degree candidacy requirements. (http://bulletin.vcu.edu/academic-regs/grad/candidacy)

Graduation requirements
As graduate students approach the end of their academic programs and the final semester of matriculation, they must make formal application to graduate. No degrees will be conferred until the application to graduate has been finalized.

Graduate students and program directors should refer to the following graduation requirements as published in the Graduate Bulletin for a complete list of instructions and a graduation checklist.

Visit the academic regulations section for additional information on graduation requirements. (http://bulletin.vcu.edu/academic-regs/grad/graduation-info)

Apply online at graduate.admissions.vcu.edu (http://www.vcu.edu/grad/candidacy)

Admission requirements

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<tr>
<th>Degree:</th>
<th>Semester(s) of entry:</th>
<th>Deadline dates:</th>
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<tr>
<td>M.S.</td>
<td>Fall</td>
<td>Mar 1</td>
<td>GRE-General</td>
</tr>
<tr>
<td></td>
<td>Spring</td>
<td>Oct 1</td>
<td>TOEFL (International students only)</td>
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In addition to the general admission requirements of the VCU Graduate School (http://bulletin.vcu.edu/graduate/study/admission-graduate-study/admission-requirements), the following requirements represent the minimum acceptable standards for admission:

1. Thirty credit hours in undergraduate mathematical sciences, computer science or related areas of which at least 18 credit hours must represent upper-level courses
2. Three letters of recommendation pertaining to the student’s potential ability as a graduate student in mathematical sciences

Provisional admission may be granted when deficiencies exist. These deficiencies must be removed by the end of the first year of residence,
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or its part-time equivalent, when the student’s application will be re-examined. Courses that are remedial or designed to remove deficiencies will not be accepted for credit hours toward the fulfillment of the course requirements for the master’s degree.

Degree requirements
In addition to the VCU Graduate School graduation requirements (http://bulletin.vcu.edu/academic-regs/grad/graduation-info), students are required to complete course work in core and elective courses and to meet the following requirements.

1. Credit hour requirements: Students in the M.S. in Mathematical Sciences program are required to earn a minimum of 30 graduate-level credit hours. At least one-half of the credit hours presented for graduation must be at the 600 level or higher.

2. Other requirements: All students must pass two comprehensive examinations: foundations of operations research, covering OPER 527 and OPER 528 and methods of operations research, covering OPER 639, OPER 643 and STAT 613. All students will be given two attempts to pass each exam. Students who receive a minimum grade of B on both OPER 527 and OPER 528 and a grade of A on at least one of the two courses will not need to take the foundations of operations research exam. Students who receive a minimum grade of B on each of OPER 639, OPER 643 and STAT 613 and a grade of A on at least one of the three courses will not need to take the methods of operations research exam.

Curriculum requirements

Concentration core courses

OPER 527  Optimization I 3
OPER 528  Stochastic Simulation 3
OPER 639  Practical Optimization 3
OPER 643  Decision and Risk Analysis 3
OPER 690  Research and Communications Seminar 3
STAT 613  Stochastic Processes 3

Additional courses
Operations research electives (Choose courses from list one below)
Operations research and allied field electives (Choose courses from list two below)

Total Hours 30

1  If a student previously received credit hours for OPER 527 and/or OPER 528 or their equivalents, then one or two other operations research courses must be taken in their place.

List one: Recommended electives in operations research

OPER 627  Optimization II 3
OPER 635  Network Models and Graph Theory 3
OPER/STAT 636  Machine Learning Algorithms 3
OPER 641  Stochastic Simulation and Monte Carlo Methods 3
OPER 645  Queuing Theory 3
OPER 647  Multiobjective Decision Analysis 3
OPER 648  Systems Reliability Analysis 3
OPER 649  Statistical Quality Control 3
OPER 691  Special Topics in Operations Research 1-3
OPER 696  Applied Project 1-3
OPER 697  Directed Research 1-3
OPER 698  Thesis 1-3
OPER 731  Discrete Optimization 3
OPER 732  Optimization Under Uncertainty 3
OPER/STAT 736  Mathematics of Knowledge and Search Engines 3
OPER 741  Advanced Stochastic Simulation 3
OPER 743  Decision Analysis II 3
OPER 791  Special Topics in Operations Research 1-3

List two: Recommended electives in operations research and allied fields
Any 500-, 600- or 700-level MATH, OPER or STAT course except the following

MATH 505  Modern Geometry
MATH 593  Internship in Mathematical Sciences
MATH 661  Number and Operations
MATH 662  Geometry and Measurement
MATH 663  Functions and Algebra
MATH 664  Statistics and Probability
MATH 665  Rational Numbers and Proportional Reasoning
MATH 667  Functions and Algebra II
MATH 698  Thesis
STAT 508  Introduction to Social Statistics
STAT 543  Statistical Methods I
STAT 608  Statistics for Social Research
STAT 696  Applied Project
STAT 698  Thesis

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Program website: stat.vcu.edu (http://www.stat.vcu.edu)