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.graduate.vcu.edu) 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-reggs)

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-reggs/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-reggs/grad/graduation-info)

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

Admission requirements

<table>
<thead>
<tr>
<th>Degree:</th>
<th>Semester(s) of entry:</th>
<th>Deadline dates:</th>
<th>Test requirements:</th>
</tr>
</thead>
<tbody>
<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>
</tr>
</tbody>
</table>

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,
Degree requirements

In addition to the VCU Graduate School graduation requirements (http://bulletin.vcu.edu/academic-reg/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

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPER 527</td>
<td>Optimization I</td>
<td>3</td>
</tr>
<tr>
<td>OPER 528</td>
<td>Stochastic Simulation</td>
<td>3</td>
</tr>
<tr>
<td>OPER 639</td>
<td>Practical Optimization</td>
<td>3</td>
</tr>
<tr>
<td>OPER 643</td>
<td>Decision and Risk Analysis</td>
<td>3</td>
</tr>
<tr>
<td>OPER 690</td>
<td>Research and Communications Seminar</td>
<td>3</td>
</tr>
<tr>
<td>STAT 613</td>
<td>Stochastic Processes</td>
<td>3</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPER 627</td>
<td>Optimization II</td>
<td>3</td>
</tr>
<tr>
<td>OPER 635</td>
<td>Network Models and Graph Theory</td>
<td>3</td>
</tr>
<tr>
<td>OPER/STAT 636</td>
<td>Machine Learning Algorithms</td>
<td>3</td>
</tr>
<tr>
<td>OPER 641</td>
<td>Stochastic Simulation and Monte Carlo Methods</td>
<td>3</td>
</tr>
<tr>
<td>OPER 645</td>
<td>Queuing Theory</td>
<td>3</td>
</tr>
<tr>
<td>OPER 647</td>
<td>Multiobjective Decision Analysis</td>
<td>3</td>
</tr>
<tr>
<td>OPER 648</td>
<td>Systems Reliability Analysis</td>
<td>3</td>
</tr>
</tbody>
</table>

List two: Recommended electives in operations research and allied fields

Any 500-, 600- or 700-level MATH, OPER or STAT course except the following

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 505</td>
<td>Modern Geometry</td>
<td></td>
</tr>
<tr>
<td>MATH 593</td>
<td>Internship in Mathematical Sciences</td>
<td></td>
</tr>
<tr>
<td>MATH 661</td>
<td>Number and Operations</td>
<td></td>
</tr>
<tr>
<td>MATH 662</td>
<td>Geometry and Measurement</td>
<td></td>
</tr>
<tr>
<td>MATH 663</td>
<td>Functions and Algebra</td>
<td></td>
</tr>
<tr>
<td>MATH 664</td>
<td>Statistics and Probability</td>
<td></td>
</tr>
<tr>
<td>MATH 665</td>
<td>Rational Numbers and Proportional Reasoning</td>
<td></td>
</tr>
<tr>
<td>MATH 667</td>
<td>Functions and Algebra II</td>
<td></td>
</tr>
<tr>
<td>MATH 698</td>
<td>Thesis</td>
<td></td>
</tr>
<tr>
<td>STAT 508</td>
<td>Introduction to Social Statistics</td>
<td></td>
</tr>
<tr>
<td>STAT 543</td>
<td>Statistical Methods I</td>
<td></td>
</tr>
<tr>
<td>STAT 608</td>
<td>Statistics for Social Research</td>
<td></td>
</tr>
<tr>
<td>STAT 696</td>
<td>Applied Project</td>
<td></td>
</tr>
<tr>
<td>STAT 698</td>
<td>Thesis</td>
<td></td>
</tr>
</tbody>
</table>

Total graduate credit hours required (minimum) 30

List one: Recommended electives in operations research

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPER 649</td>
<td>Statistical Quality Control</td>
<td>3</td>
</tr>
<tr>
<td>OPER 691</td>
<td>Special Topics in Operations Research</td>
<td>1-3</td>
</tr>
<tr>
<td>OPER 696</td>
<td>Applied Project</td>
<td>1-3</td>
</tr>
<tr>
<td>OPER 697</td>
<td>Directed Research</td>
<td>1-3</td>
</tr>
<tr>
<td>OPER 698</td>
<td>Thesis</td>
<td>1-3</td>
</tr>
<tr>
<td>OPER 731</td>
<td>Discrete Optimization</td>
<td>3</td>
</tr>
<tr>
<td>OPER 732</td>
<td>Optimization Under Uncertainty</td>
<td>3</td>
</tr>
<tr>
<td>OPER/STAT 736</td>
<td>Mathematics of Knowledge and Search Engines</td>
<td>3</td>
</tr>
<tr>
<td>OPER 741</td>
<td>Advanced Stochastic Simulation</td>
<td>3</td>
</tr>
<tr>
<td>OPER 743</td>
<td>Decision Analysis II</td>
<td>3</td>
</tr>
<tr>
<td>OPER 791</td>
<td>Special Topics in Operations Research</td>
<td>1-3</td>
</tr>
</tbody>
</table>

Graduate program director

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(804) 828-5853

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