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

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 Statistical Sciences and Operations Research, students pursuing the Bachelor of Science in Mathematical Sciences can choose a concentration of operations research, which focuses on modern mathematical techniques for solving problems arising from other fields, such as engineering, business or economics.

Learning outcomes

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

- Apply theories of mathematical programming
- Perform stochastic models and decision analysis
- Obtain, analyze and interpret data
- Use commonly used operations research software
- Identify and apply operations research models
- Develop understanding of mathematics
- Communicate technical information orally and in writing

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 operations research

General education requirements

Course	Title	Hours
University Core Education Curriculum (minimum 21 credits)		
UNIV 111 Play course video for Focused Inquiry I	Focused Inquiry I	3
UNIV 112 Play course video for Focused Inquiry II	Focused Inquiry II	3
UNIV 200	Inquiry and the Craft of Argument	3
Approved humanities/fine arts		3
Approved natural/physical sciences		3-4
Approved quantitative literacy		3-4
Approved social/behavioral sciences		3-4
Total Hours		21-24

Course	Title	Hours
Additional College of Humanities and Sciences requirements (11-23 credits)		
HUMS 202	Choices in a Consumer Society	1
Approved H&S diverse and global communities		3
Approved H&S human, social and political behavior (fulfills University Core social/behavioral sciences)		
Approved H&S literature and civilization (fulfills University Core humanities/fine arts)		
Approved H&S science and technology (fulfills University Core natural/physical sciences)		
Approved H&S general education electives		6-8
Experiential fine arts [1]		1-3
Foreign language through the 102 level (by course or placement)		0-8
Total Hours		11-23

[1] Course offered by the School of the Arts

Collateral requirements

Course	Title	Hours
Select one of the following natural science sequences:		8-10
Sequence 1		
BIOL 151 & BIOZ 151	Introduction to Biological Sciences I and Introduction to Biological Science Laboratory I	

BIOL 152 & BIOZ 152	Introduction to Biological Sciences II and Introduction to Biological Science Laboratory II	
Sequence 2		
CHEM 101 & CHEZ 101	General Chemistry I and General Chemistry Laboratory I	
CHEM 102 & CHEZ 102	General Chemistry II and General Chemistry Laboratory II	
Sequence 3		
PHYS 201 & PHYS 202	General Physics I and General Physics II	
Sequence 4		
PHYS 207 & PHYS 208	University Physics I and University Physics II	
Select another course in the natural sciences that is not from the general education science and technology list. This course must be in a science different from the sequence chosen above.		3-5
Total Hours		11-15

Major requirements

Course	Title	Hours
MATH 200 & MATH 201	Calculus with Analytic Geometry I and Calculus with Analytic Geometry II [1]	8
MATH 300	Introduction to Mathematical Reasoning [1]	3
MATH 307	Multivariate Calculus	4
MATH 310	Linear Algebra	3
OPER 327	Mathematical Modeling [1]	3
OPER 427	Deterministic Operations Research [1]	3
OPER 428	Stochastic Operations Research [1]	3
SSOR 490	Developing Professional Skills in Operations Research and Statistics (capstone) [1]	3
SSOR 495	Expositions in Statistical Sciences and Operations Research (capstone) [1]	1
STAT 212	Concepts of Statistics (fulfills University Core quantitative literacy)	
STAT 309	Introduction to Probability Theory [1]	3
STAT 403	Introduction to Stochastic Processes [1]	3
Select one of the following advanced mathematical science electives:		3
MATH 401	Introduction to Abstract Algebra [1]	
MATH 407	Advanced Calculus [1]	
MATH 409	General Topology [1]	
Select one of the following computing sequences:		6-7
CMSC 245 & CMSC 246	Introduction to Programming Using C++ and Advanced Programming Using C++	
CMSC 255 & CMSC 256	Introduction to Programming and Data Structures and Object Oriented Programming	
EGRE 245 & EGRE 246	Engineering Programming and Advanced Engineering Programming	
Select three courses from the operations research concentration electives below		9-12
Total Hours		55-59

[1] A minimum grade of C is required in these courses/credits (including both MATH 200 & MATH 201).

Open electives

Course	Title	Hours
Select 0 to 22 credits		0-22

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

Electives

For the operations research concentration, three electives must be chosen from the following list:

Course	Title	Hours
CMSC 302	Introduction to Discrete Structures	3
CMSC 303	Introduction to the Theory of Computation	3
CMSC 391	Topics in Computer Science [2]	3
CMSC 401	Algorithm Analysis with Advanced Data Structures	3
INFO 364	Database Systems	3
MATH 301	Differential Equations	3
MATH 305	Elementary Number Theory	3
MATH/BNFO/BIOL 380	Introduction to Mathematical Biology	4
MATH 391	Topics in Mathematics [2]	1-3
MATH 401	Introduction to Abstract Algebra	3
MATH 407	Advanced Calculus	3
MATH 409	General Topology	3
MATH 432	Ordinary Differential Equations	3
MATH 433	Partial Differential Equations	3
MATH 434	Discrete Dynamical Systems	3
MATH 507	Bridge to Modern Analysis	3
MATH 511	Applied Linear Algebra	3
MATH 515	Numerical Analysis	3
OPER 591	Topics in Operations Research [2]	1-3
SSOR 492	Independent Study [2]	2-4
STAT 305	Intermediate Statistics [3]	3
STAT 310	Introduction to Statistical Inference	3
STAT 314	Applications of Statistics [3]	4
STAT 321	Introduction to Statistical Computing	3
STAT 391	Topics in Statistics [2]	3
STAT 415	Statistical Consulting	3
STAT 421	Applied Statistical Computing Using R	3
STAT 422	Structured Problem Solving Using Statistics	3
STAT 423	Nonparametric Statistics	3
STAT 425	Multivariate Statistics	3
STAT 435	Industrial Statistics	3

STAT 441	Applied Statistics for Engineers and Scientists [3]	3
STAT 443	Regression	3
STAT 475	Time Series	3
STAT/BIOS 513	Mathematical Statistics I	3
STAT/BIOS 514	Mathematical Statistics II	3
STAT 544	Statistical Methods II	3
STAT 546	Linear Models	3
STAT 591	Topics in Statistics [2]	3

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Special topics and independent study courses require prior approval from the department chair or the student's adviser.

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Students may choose only one of STAT 305, STAT 314 or STAT 441.

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	4
UNIV 101	Introduction to the University	1
UNIV 111 Play course video for Focused Inquiry I	Focused Inquiry I	3
Approved H&S diverse and global communities		3
Approved H&S general education elective		3-4
	Term Hours:	14-15
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	3
Approved H&S human, social and political behavior		3-4
	Term Hours:	14-15

Sophomore year

Fall semester		
MATH 300	Introduction to Mathematical Reasoning	3
OPER 327	Mathematical Modeling	3
UNIV 200	Inquiry and the Craft of Argument	3
Computing sequence: Select one of the following:		
CMSC 245 or CMSC 255 or EGRE 245	Introduction to Programming Using C++ or Introduction to Programming or Engineering Programming	3-4
Foreign language 101		4
	Term Hours:	16-17
Spring semester		
MATH 307	Multivariate Calculus	4
MATH 310	Linear Algebra	3
Approved H&S science and technology		3-4
Computing sequence: Select one of the following with appropriate matching course from previous semester:		
CMSC 246 or CMSC 256 or EGRE 246	Advanced Programming Using C++ or Data Structures and Object Oriented Programming or Advanced Engineering Programming	3
Foreign language 102		4
	Term Hours:	17-18

Junior year

Fall semester		
STAT 309	Introduction to Probability Theory	3
Approved H&S general education elective		3-4
Experiential fine arts		1-3
Natural sciences sequence: Select one of the following:		4-5
BIOL 151 & BIOZ 151	Introduction to Biological Sciences I and Introduction to Biological Science Laboratory I	4
CHEM 101 & CHEZ 101	General Chemistry I and General Chemistry Laboratory I	4
PHYS 201	General Physics I	4
PHYS 207	University Physics I	5
Operations research concentration elective (listed below)		3-4
	Term Hours:	14-19
Spring semester		
STAT 403	Introduction to Stochastic Processes	3
Approved H&S literature and civilization		3
Natural sciences elective (not from general education science and technology list and different science than chosen for sequence)		3-5
Natural sciences sequence: Select one of the following with appropriate matching course from previous semester:		4-5
BIOL 152 & BIOZ 152	Introduction to Biological Sciences II and Introduction to Biological Science Laboratory II	4
CHEM 102 & CHEZ 102	General Chemistry II and General Chemistry Laboratory II	4
PHYS 202	General Physics II	4
PHYS 208	University Physics II	5
Operations research concentration elective (listed below)		3-4
	Term Hours:	16-20

Senior year

Fall semester		
MATH 401	Introduction to Abstract Algebra	3
OPER 427	Deterministic Operations Research	3
OPER 428	Stochastic Operations Research	3
SSOR 490	Developing Professional Skills in Operations Research and Statistics	3

Open elective		3
	Term Hours:	15
Spring semester		
SSOR 495	Expositions in Statistical Sciences and Operations Research	1
Open electives		10-12
Operations research concentration elective (listed below)		3-4
	Term Hours:	14-17
	Total Hours:	120-136

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

- Statistical Science and Operations Research (p. 4)
- Statistics (p. 4)
- Operations Research (p. 6)

Statistical Science and Operations Research

SSOR 490. Developing Professional Skills in Operations Research and Statistics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: UNIV 200 or HONR 200; either OPER 427 and OPER 428, or STAT 321 and either STAT 305 or STAT 314. Capstone course designed to help students apply analysis techniques and attain proficiency in professional and academic communication in the context of statistics and operations research. Focuses on the discipline-specific skills necessary to excel in careers or graduate studies in these disciplines.

SSOR 492. Independent Study. 2-4 Hours.
Semester course; variable hours. 2-4 credits. Maximum 4 credits per semester; maximum total of 6 credits. Generally open only to students of junior or senior standing who have acquired at least 12 credits in the departmental discipline. Determination of the amount of credit and permission of instructor and department chair must be procured prior to registration in the course. The student must submit a proposal for investigating some area or problem not contained in the regular curriculum. The results of the student's study will be presented in a report.

SSOR 493. Internship. 3 Hours.
Semester course; the equivalent of at least 15 work hours per week for a 15-week semester. 3 credits. Enrollment restricted to mathematical sciences/statistics and mathematical sciences/operations research majors only with junior or senior standing. Admission by permission from the department chair. Through placement in a position in business, industry, government or the university, the student will serve as an intern in order to obtain a broader knowledge of statistics or operations research techniques and their applications.

SSOR 495. Expositions in Statistical Sciences and Operations Research. 1 Hour.
Semester course; 1 lecture hour. 1 credit. Prerequisite: SSOR 490. Capstone course designed to help students obtain proficiency in professional writing and presentation skills. The students will present, both orally and in writing, the findings from their capstone projects.

SSOR 690. Research and Communications Seminar. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Enrollment restricted to students with nine graduate credits in OPER and/or STAT courses and with permission of the instructor. Designed to help students attain proficiency in professional and academic communication and research in the context of statistics and operations research. The course focuses on the discipline-specific communication and research skills necessary to excel in careers or graduate studies in these disciplines.

Statistics

STAT 206. Data Analysis and Statistics for Elementary Education. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Enrollment is restricted to students majoring in liberal studies for early and elementary education who have received a passing score on the PRAXIS I exam. Understanding probability, describing data both graphically and numerically, regression/correlation, common distributions and interpretation, item analysis for tests, interpreting test scores and educational studies, experimental design and limitations, comparing results using t-tests. This course relies heavily on using a graphing calculator as a data-analysis tool. Students may receive credit toward graduation for only one of STAT 206, STAT 208, STAT 210, STAT 212, STAT 312 or SCMA 301.

STAT 208. Statistical Thinking. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: satisfactory score on the VCU Mathematics Placement Test within the one-year period immediately preceding the beginning of the course, or a minimum grade of C in MATH 131, MATH 141, MATH 151, MATH 200 or MATH 201. An exploration of the use of statistics in the world around us through in-depth case studies. Emphasis is on understanding statistical studies, charts, tables and graphs frequently seen in various media sources. Some lectures involve activities centered on case studies. Students may receive credit toward graduation for only one of STAT 206, STAT 208, STAT 210, STAT 212, STAT 312 or SCMA 301.

STAT 210. Basic Practice of Statistics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: satisfactory score on the VCU Mathematics Placement Test within the one-year period immediately preceding the beginning of the course, or a minimum grade of C in MATH 131, MATH 141, MATH 151, MATH 200 or MATH 201. An exception to this policy is made in the case where the stated alternative prerequisite course has been completed at VCU. Designed for students who will likely take another quantitative reasoning course for which statistics may be a prerequisite. Not open to mathematical sciences or computer science majors. Topics include examining distributions, examining relationships, producing data, sampling distributions and probability, introduction to inference. Students may receive credit toward graduation for only one of STAT 206, STAT 208, STAT 210, STAT 212, STAT 312 or SCMA 301.

STAT 212. Concepts of Statistics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: satisfactory score on the VCU Mathematics Placement Test within the one-year period immediately preceding the beginning of the course, or MATH 151, MATH 200 or MATH 201. Introductory statistics course with an emphasis on descriptive statistics, correlation and regression, probability, normal distributions, t distributions, and statistical inference. Graphing calculators will be used extensively. A core course for mathematical sciences. Students may receive credit toward graduation for only one of STAT 206, STAT 208, STAT 210, STAT 212, STAT 312 or SCMA 301.

STAT 291. Topics in Statistics. 1-3 Hours.
Semester course; 1-3 lecture hours. 1-3 credits. A study of selected topics in statistics. Specific topics may fulfill general education requirements. See the Schedule of Classes for specific topics and prerequisites.

STAT 305. Intermediate Statistics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: MATH 200 and STAT 212, or their equivalents. A study of intermediate-level statistical inference procedures, including categorical data analysis, analysis of variance, multiple regression and nonparametric procedures. Students may receive credit toward graduation for only one of STAT 305 or STAT 314.

STAT 309. Introduction to Probability Theory. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: MATH 307 and either MATH 211 or MATH 300. A study of the mathematical theory of probability, including finite and infinite sample spaces, random variables, discrete and continuous distributions, mathematical expectation, functions of random variables and sampling distributions.

STAT 310. Introduction to Statistical Inference. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: STAT 212 and STAT 309, or permission of instructor. Framework for statistical inference. Point and interval estimation of population parameters. Hypothesis testing concepts, power functions, Neyman-Pearson lemma and likelihood ratio tests. Elementary decision theory concepts.

STAT 314. Applications of Statistics. 4 Hours.
Semester course; 4 lecture hours. 4 credits. Prerequisite: STAT 210 or 212. A study of the concepts and application of statistical methods including: estimation and hypothesis testing for two sample problems; one factor analysis of variance and multiple comparisons; randomized block designs and analysis; inferences on categorical data, including chi-square test for independence for contingency tables; simple linear regression and correlation; multiple linear regression. Special topics include distribution-free (nonparametric) methods in various statistical problems, two factor analysis of variance and the use of a statistical software package for data analysis. Students may receive credit toward graduation for only one of STAT 305 or STAT 314.

STAT 321. Introduction to Statistical Computing. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: STAT 212 and MATH 200 or their equivalents. The application of computers and computing software to statistical concepts using R, SAS and other quantitative software. Topics include data storage and retrieval, data modification and file handling, standard statistical analyses, graphical representations, practical presentation of results.

STAT 391. Topics in Statistics. 1-3 Hours.
Semester course; 1-3 lecture hours. 1-3 credits. Prerequisite: because of the changing subject matter to be treated in this course, permission of the instructor is required. A study of selected topics in statistics. See the Schedule of Classes for specific topics to be offered each semester and prerequisites.

STAT 403. Introduction to Stochastic Processes. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: MATH 307 and STAT 309. Introduction to the theory of stochastic processes and their applications. In-depth studies of random variables, conditional probability and conditional expectation. Topics include Markov chains, random walks, Poisson processes, birth and death processes and applications to classical problems (e.g., gambler's ruin, physics, etc.).

STAT 415. Statistical Consulting. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: STAT 305 and STAT 321, or their equivalents. An introduction to the techniques of statistical consulting. Topics include applying statistical concepts to real-world scenarios, dealing with messy data and communicating results.

STAT 421. Applied Statistical Computing Using R. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: MATH 310 and either STAT 305 or STAT 314, or their equivalents. Completion of STAT 321 is strongly recommended. Introduction to object-oriented programming in the R environment for use with statistical analyses. Topics include basic algorithms in R and applications involving random number generation, parametric and non-parametric data analysis and inference, linear models, simulation, and advanced data manipulation.

STAT 422. Structured Problem Solving Using Statistics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: STAT 314, PSYC 214 or SCMA 302, or permission of instructor. Focuses on using analytic frameworks and applying statistics to solve problems in a real-world environment. Topics include discussion of analytical frameworks, problem restatement, divergent/convergent thinking, causal flow diagramming, the matrix method, decision tree analysis, review of sampling, confidence intervals, regression, ANOVA, chi squared tests, as well as applications of these concepts to solve case studies.

STAT 423. Nonparametric Statistics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: STAT 305 and STAT 321. Introduction to statistical estimation and inference methods that require relatively mild assumptions about the underlying population distribution. Topics include classical nonparametric hypothesis testing methods, permutation tests, bootstrap methods and density estimation.

STAT 425. Multivariate Statistics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: MATH 307, MATH 310, STAT 309, and either STAT 305 or STAT 314. Completion of STAT 421 is strongly recommended. Introduction to multivariate statistical analysis methods. Topics include multivariate probability distributions and their properties, conditional and marginal distributions, multivariate normal distribution, Hotelling's T2 distribution, multivariate analysis of variance, repeated measures, multivariate regression, principle component analysis, exploratory factor analysis, linear discriminant analysis, cluster analysis, and regression trees. Students will use modern statistical software to perform these analyses.

STAT 435. Industrial Statistics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: STAT 309; and STAT 305 or STAT 314. Introduction to statistical methods for quality control and process improvement. Topics include special versus common causes of variation, statistical thinking in industrial settings, Shewhart control charts, capability analysis, components of variation, design of experiments and response surface methods. Incorporates use of statistical software.

STAT 441. Applied Statistics for Engineers and Scientists. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: MATH 201 or equivalent. An introduction to applied statistics intended primarily for students in engineering. The fundamental ideas about the collection and display of information, descriptive statistics and exploratory data analysis, elementary probability theory, frequency distributions, and sampling are covered. Other topics include tests of hypotheses and confidence intervals for one and two sample problems; ANOVA; principles of one-factor experimental designs including randomized complete block designs, fixed and random effects and multiple comparisons; correlation and linear regression analysis; control charts; contingency tables and goodness-of-fit. Statistical software is used extensively in this course, so a working knowledge of computers is necessary. Students may receive degree credit for only one of BIOS 543, STAT 441, STAT 541, STAT 543 or STAT 641.

STAT 443. Regression. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: STAT 305 and STAT 321, or permission of instructor. Completion of MATH 310 is strongly recommended. Introduction to the concepts and methods of linear regression, logistic regression, and other nonlinear regression models. Topics include model development and assumptions, estimation of model parameters, statistical inferences about the regression model, selection of an appropriate model, and diagnostics regarding multicollinearity and influence points. Applications involve the use of a statistical software package.

STAT 475. Time Series. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: STAT 321 and either STAT 305 or STAT 314. Completion of STAT 421 is strongly recommended. Introduction to the modeling of univariate time series data. Topics include simple and exponential moving averages, Brown's double exponential smoothing, Holt-Winters model, autocorrelation, partial autocorrelation, autoregressive integrated moving average models, seasonal autoregressive moving average models, harmonic analysis and time series regression. Students will use modern statistical software to perform these analyses.

Operations Research

OPER 327. Mathematical Modeling. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: MATH 200. Fundamental concepts of mathematical modeling. Topics may include differential equation models, optimization models and probabilistic models. Practical problems will be discussed throughout.

OPER 391. Topics in Operations Research. 1-3 Hours.
Semester course; 1-3 lecture hours. 1-3 credits. May be repeated with different topics for a maximum of 6 credits. A study of selected topics in operations research. See the Schedule of Classes for specific topics to be offered each semester and prerequisites. Because of the changing subject matter to be treated in this course, enrollment requires permission of the instructor.

OPER 427. Deterministic Operations Research. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: CMSC 245 or CMSC 255, MATH 310 and OPER 327. Introduction to topics in optimization including linear programming, network models and integer programming. Focuses on constructing sound models and on solving them using appropriate software. Algorithms and model properties are also discussed. Students may not receive degree credit for both OPER 427 and OPER 527.

OPER 428. Stochastic Operations Research. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: CMSC 245 or CMSC 255, MATH 310 and STAT 309. Introduction to topics in discrete-event and Monte Carlo simulation including the application of probabilistic models in real-world situations, random number generation, random variate generation and Monte Carlo integration. Students may not receive degree credit for both OPER 428 and OPER 528.