

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.

Student 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

| Course | Title | Hours |
|---|--|-------|
| General education (http://bulletin.vcu.edu/undergraduate/undergraduate-study/general-education-curriculum/) | | |
| Select 12-13 credits from general education foundations and 17-18 credits from areas of inquiry. | | 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 300 | Introduction to Mathematical Reasoning ¹ | 3 |
| SSOR 490 | Developing Professional Skills in Operations Research and Statistics ¹ | 3 |
| SSOR 495 | Expositions in Statistical Sciences and Operations Research ¹ | 1 |
| STAT 309 | Introduction to Probability Theory ¹ | 3 |
| • Concentration requirements | | |
| MATH 401 or MATH 407 or MATH 409 | Introduction to Abstract Algebra ¹ Advanced Calculus General Topology | 3 |
| OPER 327 | Mathematical Modeling ¹ | 3 |
| OPER 427 | Deterministic Operations Research ¹ | 3 |
| OPER 428 | Stochastic Operations Research ¹ | 3 |
| STAT 403 | Introduction to Stochastic Processes ¹ | 3 |
| 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 | |
| Concentration electives | | |
| Select from concentration electives below. | | 9-12 |
| Ancillary requirements | | |
| HUMS 202 | Choices in a Consumer Society | 1 |
| MATH 200 | Calculus with Analytic Geometry I ¹ | 4 |
| STAT 212 | Concepts of Statistics (satisfies general education quantitative foundations) | 3 |
| Experiential fine arts ² | | 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. | 9-25 |
| Total Hours | 120 |

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These courses/credits require a minimum grade of C.

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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 |

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 ¹ | 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 380 | Introduction to Mathematical Biology | 4 |
| MATH 391 | Topics in Mathematics ¹ | 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 ¹ | 1-3 |
| SSOR 492 | Independent Study ¹ | 2-4 |
| STAT 305 | Intermediate Statistics ² | 3 |
| STAT 310 | Introduction to Statistical Inference | 3 |
| STAT 314 | Applications of Statistics ² | 4 |
| STAT 321 | Introduction to Statistical Computing | 3 |
| STAT 391 | Topics in Statistics ¹ | 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 ¹ | 3 |

1

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

2

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 | Focused Inquiry I (satisfies general education UNIV foundations) | 3 |
| Play course | video for Focused Inquiry I | |
| | General education course (select AOI for creativity, innovation and aesthetic inquiry) | 3 |
| | General education course (select AOI for diversities in the human experience) | 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 (satisfies general education quantitative foundations) | 3 |
| UNIV 112 | Focused Inquiry II (satisfies general education UNIV foundations) | 3 |
| Play course | video for Focused Inquiry II | |
| | General education course (select AOI for global perspectives) | 3 |
| Term Hours: | | 14 |

Sophomore year

| Fall semester | | Hours |
|----------------------|--|-------|
| MATH 300 | Introduction to Mathematical Reasoning | 3 |
| OPER 327 | Mathematical Modeling | 3 |
| UNIV 200 | Inquiry and the Craft of Argument (satisfies general education UNIV foundations) | 3 |
| Computing sequence: | | |
| CMSC 245 | Introduction to Programming Using C++ | 3-4 |
| or | or Introduction to Programming | |
| CMSC 255 | or Engineering Programming | |
| or | | |
| EGRE 245 | | |
| Foreign language 101 | | 3 |
| Term Hours: | | 15-16 |

Spring semester

| | | |
|--|--|---|
| MATH 307 | Multivariate Calculus | 4 |
| MATH 310 | Linear Algebra | 3 |
| Computing sequence: Select appropriate matching course from previous semester. | | |
| CMSC 246 | Advanced Programming Using C++ | 3 |
| or | or Data Structures and Object Oriented Programming | |
| CMSC 256 | | |
| or | or Advanced Engineering Programming | |
| EGRE 246 | | |
| Foreign language 102 | | 3 |

| | |
|--|----|
| General education course (select BOK to complete breadth of knowledge requirement) | 3 |
| Term Hours: | 16 |

Junior year

| Fall semester | | Hours |
|---|---|-------|
| STAT 309 | Introduction to Probability Theory | 3 |
| Concentration elective | | 3-4 |
| Experiential fine arts | | 1-3 |
| General education course (select BOK to complete breadth of knowledge requirement) | | 3 |
| 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 | Introduction to Biological Sciences I | - |
| & BIOZ 151 | and Introduction to Biological Science Laboratory I | - |
| CHEM 101 | General Chemistry I | - |
| & CHEZ 101 | and General Chemistry Laboratory I | - |
| PHYS 201 | General Physics I | - |
| PHYS 207 | University Physics I | - |
| Term Hours: | | 14-18 |

Spring semester

| | | |
|--|--|-------|
| STAT 403 | Introduction to Stochastic Processes | 3 |
| Concentration elective | | 3-4 |
| Natural sciences elective ¹ | | 3-5 |
| Natural sciences sequence (Select one of the following with appropriate matching course from previous semester.) | | 4-5 |
| BIOL 152 | Introduction to Biological Sciences II | - |
| & BIOZ 152 | and Introduction to Biological Science Laboratory II | - |
| CHEM 102 | General Chemistry II | - |
| & CHEZ 102 | and General Chemistry Laboratory II | - |
| PHYS 202 | General Physics II | - |
| PHYS 208 | University Physics II | - |
| Open elective | | 3 |
| Term Hours: | | 16-20 |

Senior year

| Fall semester | | Hours |
|------------------------|--|---------|
| 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 | | Hours |
| SSOR 495 | Expositions in Statistical Sciences and Operations Research | 1 |
| Concentration elective | | 3-4 |
| Open electives | | 12 |
| Term Hours: | | 16-17 |
| Total Hours: | | 120-130 |

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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 to earn both the B.S. and M.S. in Mathematical Sciences with concentration in operations research 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 nine hours of graduate courses toward both the B.S. and M.S. degrees. Thus, the two degrees may be earned with a minimum of 141 credits rather than the 150 credits necessary if the two degrees are pursued separately.

Students holding these degrees will demonstrate a comprehensive understanding of the theory and application of mathematical programming and of stochastic models. They will know how to obtain, analyze and interpret data, and learn how to use software common in the industry, allowing them to model operations research problems. Students will know how to clearly and concisely present technical information in writing and through oral presentations. The program will also provide students with opportunities to participate in research projects, internships and other training programs where they develop the skills to evaluate, refine and apply what they learn in the classroom.

Admission to the program

Minimum qualifications for admittance to the program include completion of 90 undergraduate credit hours including MATH 200, MATH 201 and MATH 307 (calculus sequence), STAT 212, STAT 309, OPER 327 and STAT 403; an overall minimum GPA of 3.0; and a minimum GPA of 3.3 in mathematics, operations research and statistics course work. Successful applicants would enter the program in the fall semester of their senior year. (Optional: Students who do not meet the minimum GPA requirements may submit GRE scores to receive further consideration.)

Undergraduate students must have departmental approval to participate in an accelerated program and must apply for admission to the master's program prior to beginning their final year of full-time undergraduate study. The entry term for the master's program will be the next available admission term following the last semester of undergraduate study. Admission to the master's program is provisional until the undergraduate degree has been conferred. Upon completion and conferral of the undergraduate degree, students are fully admitted to the master's program.

Candidates should submit applications for admission immediately following the spring of their junior year, but no later than the M.S. program admission deadline. Three reference letters (at least one from a department faculty member) must accompany the application. The adviser of graduate studies for the mathematical sciences master's program with a concentration in operations research will provide guidance of students in this program. Students who are interested in the accelerated program should consult with the faculty adviser to the operations research concentration of the M.S. program before they have completed 90 credits.

Once admitted into 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 mathematical sciences adviser and the faculty adviser to the graduate program.

Degree requirements

The Bachelor of Science in Mathematical Sciences degree with concentration in operations research 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. Nine of these credits are shared with the graduate program, meaning that they will be applied to both undergraduate and graduate degree requirements.

The graduate operations research and statistics courses that may be taken as an undergraduate, once a student is admitted to the program, are in the table below.

| Course | Title | Hours |
|---|-----------------------|-------|
| OPER 527 | Optimization I | 3 |
| OPER 528 | Stochastic Simulation | 3 |
| Approved 500-level OPER or STAT course, or approved 600-level OPER or STAT with OPER 527 or OPER 528 as prerequisites | | 3 |
| Approved 500-level or 600-level OPER or STAT course | | 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 | | |
| STAT 309 | Introduction to Probability Theory | 3 |
| | Experiential fine arts | 1-3 |
| | General education course | 3-4 |
| | Natural science sequence | 4-5 |
| | Operations research concentration elective | 3-4 |
| | Term Hours: | 14-19 |
| Spring semester | | |
| STAT 403 | Introduction to Stochastic Processes | 3 |
| | General education course | 3-4 |
| | Natural sciences elective (not from general education science and technology list and different science than chosen for sequence) | 3-5 |
| | Natural science sequence | 4-5 |
| | Operations research concentration elective | 3-4 |
| | Term Hours: | 16-20 |
| Senior year | | |
| Fall semester | | |
| OPER 528 | Stochastic Simulation | 3 |
| SSOR 490 | Developing Professional Skills in Operations Research and Statistics | 3 |
| | Advanced mathematical science elective | 3 |
| | Open electives | 15 |

| | | |
|--|---|-------|
| Term Hours: | | 15 |
| Spring semester | | |
| OPER 527 | Optimization I | 3 |
| SSOR 495 | Expositions in Statistical Sciences and Operations Research | 1 |
| Open electives | | 6-8 |
| Operations research concentration elective | | 3-4 |
| Term Hours: | | 13-16 |
| Fifth year | | |
| Fall semester | | |
| OPER 639 | Practical Optimization | 3 |
| SSOR 690 | Research and Communications Seminar | 3 |
| Graduate operations research electives | | 6 |
| Term Hours: | | 12 |
| Spring semester | | |
| OPER 643 | Decision and Risk Analysis | 3 |
| STAT 613 | Stochastic Processes | 3 |
| Graduate operations research elective | | 3 |
| Term Hours: | | 9 |

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- Statistics (p. 5)
- Operations Research (p. 7)

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 MATH 131, MATH 141, MATH 151, MATH 200 or MATH 201. 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.