MASTER OF SCIENCE IN OPERATIONS RESEARCH

December 2019

Version 13

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The Systems Engineering and Operations Research Department (SEOR)
is located in Room 2100, Nguyen Engineering Building.

GEORGE MASON UNIVERSITY

VOLGENAU SCHOOL OF ENGINEERING

GRADUATE STUDIES IN OPERATIONS RESEARCH

The Department of Systems Engineering and Operations Research is one of the eight departments comprising the Volgenau School of Engineering, the others being Information Sciences and Technology, Statistics, Computer Science, Electrical & Computer Engineering, Civil, Environmental and Infrastructure Engineering, Bioengineering and Mechanical Engineering.

The applied scientific discipline of operations research (OR) - also called management science (MS) or operations engineering (OE) - is the professional field that deals with the use of scientific methods in management decision making, especially for the best allocation of limited resources. As scientists and engineers, operations researchers do for organizations what physicists do for the physical world: they try to find order in apparent chaos by identifying the structure in complex situations and understanding how the components of organizations interact, in order to explain and predict the effects of actions taken on these systems. Much of this work is done using analytical and numerical techniques, by developing and manipulating mathematical and computer models of organizational systems composed of people, machines, information, and procedures. The overall purpose of operations research is thus to provide a rational and quantitative basis for making decisions.

Operations research workers may be involved in a spectrum of professional activities ranging from the theoretical to the applied. They may work in industry, in government or in universities. They may teach, do research, and/or solve real problems. Operations researchers may be involved in just one phase of an OR study, such as mathematical modeling, analysis, or its eventual application, or they may participate in all portions of a project; and many OR workers have passed from the technical aspects of OR to purely managerial functions.

The focus of research activities among the operations research and engineering faculty at GMU is on the development, solution and application of models, with particular emphasis on computational feasibility. The faculty and students of the department have access to a wide range of computational alternatives and an extensive collection of state-of-the-art equipment. Faculty and graduate students in the Department are also able to use university-wide computers, many of which are available through easily reached local networks.

The Department offers a Master of Science degree in Operations Research. Students with special interests in Optimization, Stochastic Modeling, Decision Analysis, Military Operations Research or Financial Engineering may elect to concentrate in these areas. In addition, the Department offers the Ph.D. program in Systems Engineering and Operations Research.

The graduate program leading to an MS in Operations Research prepares students for research and professional practice associated with the formulation and analysis of mathematical models for decision making, and their computer implementation. Major components of the program include optimization, queuing and network modeling, computer simulation and modeling, applied and computational probability, and application of these components to realistic and relevant operational analysis problems. Students are expected to become proficient in these areas, as well as in supporting areas of information technology necessary to implement operations research methods.

To achieve this objective, the program includes core courses and electives selected by the student with the aid of a faculty advisor. To obtain the Master of Science degree, students must complete a minimum of 30 graduate credits.

M.S. IN OPERATIONS RESEARCH
ADMISSION REQUIREMENTS

In addition to the Graduate School general admission requirements, candidates must meet the following requirements:

1. Have a baccalaureate degree from an accredited institution in engineering, mathematics, computer science, physical sciences, economics, or a related field.
2. Have completed courses in calculus (MATH 113, 114, and 213), matrix algebra (MATH 203), differential equations (MATH 214), applied probability and statistics (STAT 346), and a scientific programming language (CS 112).
3. Provide evidence of satisfactory educational achievement in at least one of the following forms: a GPA of at least 3.000 as an undergraduate, or an acceptable GPA in graduate courses. International students must also achieve satisfactory scores on the Graduate Record Examination (GRE).
4. Have achieved a satisfactory score on the TOEFL examination for non-native English speakers.
5. Have two letters of recommendation submitted by former professors or supervisors.

The department offers SYST 500 as an intensive review of undergraduate engineering mathematics, including matrix algebra, transforms, differential equations, probability, and statistics. Upon acceptance, each student will be required to take a foundation qualification test a week or two before the school starts unless waived by the department chair or graduate coordinator. Students who fail the test will be required to take SYST 500. A sample test is available from the department.

Students with minor deficiencies in preparation may be accepted conditionally pending removal of the deficiencies. Courses taken to remove admission deficiencies (including SYST 500) extend the minimum requirements for the degree. Students whose undergraduate training was in the quantitative social sciences or quantitatively oriented business administration may be allowed to complete a portion of the mathematics prerequisite by taking SYST 500.

Acceptance to the degree program is based on an assessment of the capacity of the applicant to pursue the graduate program successfully, using factors such as the undergraduate record and professional work experience. Students who are exceptionally well qualified but have minor deficiencies (one or two courses) may be admitted conditionally, subject to completion of the appropriate undergraduate coursework.

DEGREE REQUIREMENTS

To obtain the Master of Science degree in Operations Research, completion of an approved plan of study with a minimum of 30 semester hours (10 courses) of graduate level coursework is required. The program contains four core courses which provide students with a comprehensive understanding of the basic techniques and applications of operations research. In addition each student must complete an applied team project in the project course OR 699. The remaining five courses are chosen by the student and faculty advisor to reflect the student's interests.

Required Core Courses (12 credits):

OR 541 Operations Research: Deterministic Models
OR 542 Operations Research: Stochastic Models
OR 568 Applied Predictive Analytics
OR 635 Discrete System Simulation

Project (3 credits):

OR 699 Masters Project

Students should take this course in their last semester of studies.

Methods Courses (6 credits):
Students should take at least one deterministic methods and one stochastic methods course.

Deterministic methods courses:

OR 641 Linear Programming
OR 642 Integer Programming
OR 643 Network Modeling
OR 644 Nonlinear Programming
OR 670 Metaheuristics for Optimization

Stochastic methods courses:

OR 645 Stochastic Processes
OR 647 Queuing Theory
OR 674 Dynamic Programming
OR 675 Reliability Analysis
SYST 664 Bayesian Inference and Decision Theory

Additional Electives (9 credits):
Up to three additional elective courses may be chosen with the written concurrence of the student's advisor. At least two of these electives must be taken from SEOR course offerings, and one of these must be OR 600-level or higher. The remaining course should be taken in an area appropriate to the student's interests, such as operations research, systems engineering, statistics, computer science, information systems, electrical and computer engineering, data analytics, economics, mathematics, or supply chain management.

Concentration Areas:

Students may construct concentration areas by choosing electives from among special groupings. The six concentrations available are: Optimization, Stochastic Modeling, Decision Analysis, Military Operations Research, Data Analytics and Financial Engineering. In addition to the required core courses (12 credits) and project course (3 credits), the remaining 15 credit hours consist of methods and elective courses associated with the concentration areas as outlined below. Students can also devise their own grouping of electives subject to approval by their advisor.

Students opting to concentrate in Optimization must complete three courses from OR 604, 641, 642, 643, 644, 682, and 670. The remaining two courses are chosen with the written concurrence of the advisor and must include at least one stochastic methods course.

Students concentrating in Stochastic Modeling must complete three courses from OR 645, 647, 674, 719, SYST 664 and either STAT 554 or STAT 663. The remaining two courses are chosen with the written concurrence of the student's advisor and must include at least one deterministic methods course.

Students concentrating in Decision Analysis must complete OR 671 and 681 and SYST 664. The remaining two electives must include one deterministic methods course and one stochastic methods course.

Students concentrating in Military Operations Research must complete OR 651, 652 and SYST 683. The remaining two courses must include one deterministic methods course and one stochastic methods course.

Students concentrating in Data Analytics must complete CS504 and two course from OR 604, 670, STAT 663 and 664. The remaining two courses must include one deterministic methods course and one stochastic methods course.

Finally, students concentrating in Financial Engineering must complete OR 588 and 688 and one course from OR 538, 645, 671, 681 and 682. The remaining two electives must include one deterministic methods course and one stochastic methods course (if the student has already taken OR 645 this can be substituted for an elective course with written concurrence of the student's advisor).

Allowable Elective:

The allowable elective for M.S. students includes:

A. Within VSE:
   - Any OR course ≥600
   - Any SYST course > 500
   - Any STAT course ≥ 554
   - Any CS course ≥ 500
   - Any ECE course≥ 500 but not 528
   - Any CEIE course > 500 but not 601

B. External to VSE (subject to approval by the Department Chair):
   - Any MATH course ≥ 601 and permitted for Math majors;
   - Any CSI course > 610
   - any ECON course ≥ 611

CERTIFICATE PROGRAMS

Certificate Program in Computational Modeling. The certificate program in computational modeling provides knowledge, tools, and techniques to those who are working, or planning to work, in the field of computational modeling. Courses taken for this certificate program can count toward a master's in operations research or statistics, or a Ph.D. in Computational Sciences and Informatics. One must be concurrently enrolled in the program for courses to count toward both the certificate and the other degree. For admission into the certificate program, the applicants must meet either the minimum entrance requirements for the M.S. in Operations Research, the M.S. in Statistical Science, or the entrance requirements for the Ph.D. in Computational Sciences and Informatics. Certificate candidates must complete the following three courses: OR 541, 635 and either OR 682 or MATH 685. In addition, candidates must choose any one of the following electives: ECE 521, MATH 673, OR 542, SYST 611, SYST 683, and CSI 744.

Certificate Program in Military Operations Research. The certificate program in military operations research provides knowledge, tools, and techniques to those who are working, or planning to work, in the field of military operations research. It is appropriate for students who cannot complete all the requirements for a master's degree in operations research, but who want a concentrated study of military modeling, as well as for students admitted to the MS in Operations research or systems engineering, Admissions requirements to this program are identical to those for the master's degree in operations research. Certificate candidates must complete five courses, with an average grade of B or better, for a total of 15 graduate credits. To obtain the certificate, a student needs to complete the following: OR 541, 635, 651, 652, and SYST 683.

Certificate Program in Data Analytics. The certificate program in Data Analytics provides a broad overview of the end-to-end value chain for Big Data Analytics, from the capture and management of the data, through the analytics that harness the data to create value. The certificate is designed to provide a framework for the methodologies for organizing and integrating disparate data, analyzing and visualizing the integrated data, and determining what decisions or actions should be taken to generate value from the data. This certificate is intended for students who are interested in addressing the challenge of transforming the massive data arising in applications such as business analytics, cyber defense/forensics, energy, finance,

genomics, healthcare, intelligence, law enforcement, or transportation, into meaningful information. While no specific undergraduate degree is required, a background in engineering, business, computer science, math, or information technology is desirable; alternatively, strong work experience with data or analytics may be used. To obtain the certificate, a student must achieve a total GPA of at least 3.00, with no more than three credits of a grade of C from the following courses: AIT 580, CS 504, OR 531, and STAT 515.

DOCTORAL LEVEL STUDIES

The SEOR Department offers a program leading to the PhD in Systems Engineering and Operations Research. A brochure describing this program may be obtained from the Department.

Operation Research Course Descriptions (OR)

Descriptions of OR graduate courses offered by the Department of Systems Engineering and Operations Research follow.

538/SYST 538 Analytics for Financial Engineering and Econometrics (3:3:0)
Prerequisite: STAT 515 or STST 544.
This course introduces the basic analytics for financial engineering and econometrics, topics include financial transactions and econometric data management, correlation, linear and multiple regressions for financial and economic predictions, financial time series analysis, portfolio theory and risk analysis. It will provide a foundation of basic theory and methodology as well as applied examples with techniques to analyzing large financial and econometric data. Hand-on experiments with *R* will be emphasized throughout the course.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges

540/SYST 540 Management Science (3:3:0)
Prerequisites: MATH 108, and STAT 250 or OM 200; or equivalent.
Operations research techniques and their application to managerial decision making. Mathematical programming, Markov processes, queuing theory, inventory models, PERT, CPM, and computer simulation are covered, as well as use of contemporary computer software for problem solving. Case-study approach to problem solving is used. Students who have taken OR 541 or OR 542 and OR MS majors do not receive credit.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges

541 Operations Research: Deterministic Models (3:3:0)
Prerequisite: MATH 203 or equivalent.
Survey of deterministic methods of solving real world decision problems. Covers linear programming model and simplex method of solution, duality, and sensitivity analysis, transportation and assignment problems; shortest path, minimal spanning tree, and maximal flow problems; and an introduction to integer and nonlinear programming. Emphasis on modeling and problem solving. Students who have taken OR 441/MATH 441 will not receive credit.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges

542 Operations Research: Stochastic Models (3:3:0)
Prerequisite: STAT 344 or MATH 351, or equivalent.

A survey of probabilistic methods for solving decision problems under uncertainty, probability theory review, reliability, queuing theory, inventory systems, Markov chain models, and simulation. Emphasis on modeling and problem solving. Students who have taken OR 442/MATH 442 do not receive credit.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Students in a Non-Degree Undergraduate degree may not enroll.
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568/SYST 568 Applied Predictive Analytics (3:3:0)
Prerequisite(s): STAT 515 or Graduate Standing at the MSOR or MSSE programs.
Introduces predictive analytics with applications in engineering, business, and econometrics. Topics include time series and cross-sectional data processing, correlation, linear and multiple regressions, time series decomposition, predictive modeling and case study. Provides a foundation of basic theory and methodology with applied examples to analyze large engineering and econometric data for predictive decision making. Hand-on experiments with R will be emphasized.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges

574/SYST 574 Quality Control and Process Management (3:3:0)
Prerequisite: Graduate standing or permission of instructor.
Provides fundamentals of quality control and process management methodologies that are applicable in manufacturing industries. Introduces the basic concepts of engineering process and product quality management techniques. Provides exposition of fundamentals of lean Six Sigma and total quality management and maintainability.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges

576/SYST 576 Manufacturing Systems Analysis (3:3:0)
Prerequisites: Graduate standing or permission of instructor.
Provides fundamentals of modeling and analysis of general manufacturing systems that are also applicable to semiconductor manufacturing. Introduces the basic concepts of scheduling, inventory control, and enterprise resource management.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Students in a Non-Degree Undergraduate degree may not enroll.
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588/SYST 588 Financial Systems Engineering I: Intro to Options, Futures, and Derivatives (3:3:0)
Prerequisite: Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Students in a Non-Degree Undergraduate degree may **not** enroll.
This course is an introduction to financial engineering. Financial engineering is a cross-disciplinary field which relies on mathematical finance, numerical methods, and computer simulations to make trading, hedging, and investment decisions. This course will introduce basic types of derivatives, such as forward, futures, swaps, and options; as well as financial models such as Brownian motion, Ito's formula, and Black-Scholes model.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Students in a Non-Degree Undergraduate degree may not enroll.
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603 Sports Analytics (3:3:0)
Prerequisite: OR 531 or OR 541 and STAT 518 or OR 568
Cover topics in the applied analysis of sports, with a focus on supporting team decision-makers. Students will learn to apply modern, practical analytic techniques to sports data in search of actionable insight and a competitive edge. The four major team sports of North America (football, baseball, basketball, and

hockey) will be the primary subjects of study, but the course's learning objectives will universally apply to a variety of sports. Students will become familiar with the full analytic life-cycle: asking productive and relevant research questions, finding the right data, applying the appropriate tools, discovering insight, and clearly communicating results.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Students in a Non-Degree Undergraduate degree may **not** enroll.
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604 Practical Optimization (3:3:0)
Prerequisite: OR 531 and CS 504
Survey of optimization methods for students whose main focus is on application of optimization. Covers modeling, search methods, convexity, linear programming, sensitivity, networks, multiobjective optimization, heuristic methods, integer programming, nonlinear programming and dynamic programming; use of modeling languages and optimization tools, including NEOS.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Students in a Non-Degree Undergraduate degree may **not** enroll.
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635 Discrete System Simulation (3:3:0)
Prerequisite: OR 542, or STAT 354 or 344, or equivalent; and knowledge of scientific programming language.
Computer simulation as a scientific methodology in operations analysis, with emphasis on model development, implementation, and analysis of results. Discrete-event models, specialized software, input modeling, and output statistics are covered. Extensive computational work is required.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Students in a Non-Degree Undergraduate degree may **not** enroll.
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640 Global Optimization and Computational Intelligence (3:3:0)
Prerequisites: MATH 203 or equivalent, and knowledge of a scientific programming language.
Introduction to global optimization of nonconvex mathematical programs and numerical methods for the solution of such problems. Topics covered include high-level survey of traditional mathematical programming algorithms; critical comparison of metaheuristics and artificial intelligence (AI) algorithms to traditional mathematical programming algorithms; probabilistic search, multistart methods, statistical tests of performance and confidence, simulated annealing, genetic algorithms, neural networks, Tabu search, homotopies and tunneling; the traveling salesman problem, the Steiner problem, Stackelberg-Cournot-Nash mathematical games and other classical nonconvex optimization problems.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Students in a Non-Degree Undergraduate degree may **not** enroll.
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641 Linear Programming (3:3:0)
Prerequisite: OR 541, or permission of instructor.
In-depth look at the theory and methodology of linear programming: Computational enhancements of the revised simplex method; sparse-matrix techniques, bounded variables and the dual simplex method. Alternative interior point methods described and computational complexity of various algorithms analyzed.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Students in a Non-Degree Undergraduate degree may **not** enroll.
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642 Integer Programming (3:3:0)
Prerequisite: OR 541, or permission of instructor.
Cutting plane and enumeration algorithms for solution of integer linear programs; bounding strategies and reformulation techniques; heuristic approaches to the solution of complex problems; knapsack problems,

matching problems, set covering and partitioning problems; applications to problems in OR/MS, such as capital budgeting, facility location, political redistricting, engineering design, and scheduling.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Students in a Non-Degree Undergraduate degree may **not** enroll.
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643 Network Modeling (3:3:0)
Prerequisite: OR 541, or permission of instructor.
Introduction to network problems in operations research, computer science, electrical engineering, and systems engineering. Solution techniques for various classes of such problems are developed. Topics include minimal-cost network flow, maximal flow, shortest path, and generalized networks; plus stochastic networks, network reliability, and combinatorially based network problems. Complexity of each problem class analyzed.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Students in a Non-Degree Undergraduate degree may **not** enroll.
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644 Nonlinear Programming (3:3:0)
Prerequisites: MATH 213 or equivalent, and OR 541; or permission of instructor.
Nonlinear optimization theory and techniques applicable to problems in engineering, economics, operations research, and management science. Covers convex sets and functions, optimality criteria and duality; algorithms for unconstrained minimization, including descent methods, conjugate directions, Newton-type and quasi-Newton methods; and algorithms for constrained optimization, including active set methods and penalty and barrier methods.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Students in a Non-Degree Undergraduate degree may **not** enroll.
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645 Stochastic Processes (3:3:0)
Prerequisite: OR 542 or STAT 544, or permission of instructor.
Selected applied probability models including Poisson processes, discrete- and continuous-time Markov chains, renewal and regenerative processes, semi-Markov processes, queuing and inventory systems, reliability theory, and stochastic networks. Emphasis on applications in practice as well as analytical models.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Students in a Non-Degree Undergraduate degree may **not** enroll.
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647 Queuing Theory (3:3:0)
Prerequisite: OR 542, STAT 544, or permission of instructor.
Unified approach to queuing, organized by type of model. Single- and multiple- channel exponential queues; Erlangian models, bulk and priority queues, networks of queues; general arrival and/ or service times; and statistical inference and simulation of queues are covered. Extensive use of computational software.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Students in a Non-Degree Undergraduate degree may **not** enroll.
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649 Topics in Operations Research (3:3:0)
Prerequisite: permission of instructor.
Advanced topic chosen according to interests of students and instructor from dynamic programming, inventory theory, queuing theory, Markov and semi-Markov decision processes, reliability theory, decision theory, network flows, large-scale linear programming, nonlinear programming, and combinatorics. May be repeated for maximum 6 credits if topics are substantially different.

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Students in a Non-Degree Undergraduate degree may **not** enroll.
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651 Military Operations Research I: Cost Analysis (3:3:0)
Corequisite: OR 541 or 542.
While drawing on other disciplines (managerial accounting, econometrics, systems analysis), cost analysis uses operations research to assist decision makers in choosing preferred future courses of action by evaluating selected alternatives on the basis of their costs, benefits, and risks. Cost analysis is distinctly different from cost estimating in that projecting future courses of action almost always requires mathematical modeling. Topics include analysis overview, economic analysis, estimating relationships (factors, simple and complex models), acquiring and verifying cost data, cost progress curves, life cycle costing, scheduling estimating, effectiveness and risk estimation, relationship of effectiveness models and measures to cost analysis.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Students in a Non-Degree Undergraduate degree may **not** enroll.
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652 Military Operations Research Modeling II: Effectiveness Analysis (3:3:0)
Corequisite: OR 541 or 542.
Examines issues and modeling underlying military decisions at the Military Service, Joint Staff, and Department of Defense level. Analytical methods with applications to theater campaign analysis, equipment and weapon system modernization, force structure development, strategic mobility and deployment, small scale contingency operations, logistics, and requirements determination are considered. Optimization, simulation, and statistical techniques are stressed. Realistic problems presented and solved as case studies. Display of results and presentation techniques for military decision makers emphasized.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Students in a Non-Degree Undergraduate degree may **not** enroll.
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660/SYST 660 Air Transportation Systems Modeling (3:3:0)
Prerequisite: SYST 460/560, or permission of instructor.
Introduces range of current issues in air transportation, including public policy toward the industry, industry economics, system capacity, current system modeling capability, human factors considerations, safety analysis and surveillance systems, and new technological developments. Students expected to develop broad understanding of contemporary and future issues. Knowledge evaluated through class discussions, a take-home midterm exam and a term project to be completed by the end of the semester.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Students in a Non-Degree Undergraduate degree may **not** enroll.
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670/SYST 670 Metaheuristics for Optimization (3:3:0)
Prerequisite: OR 441/541 or permission of instructor.
Course on the theory and practice of metaheuristics, i.e. solution search techniques for solving combinatorial optimization problems. It will introduce the theory, applications (scheduling in manufacturing, transportation, and in other engineering and service industries), and computational aspects of directly searching for solutions to solve computationally complex optimization problems without a well-defined analytical model. May not be repeated for credit
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Students in a Non-Degree Undergraduate degree may **not** enroll.
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671/SYST 671 Judgment and Choice Processing and Decision Making (3:3:0)
Prerequisite: STAT 344, 354, or STAT 542, or permission of instructor

How do people make judgments and decisions? Course presents an initial review of scientific literature directed toward answering this question, and emphasizes its importance when performing decision analysis and designing systems to support judgment and decision processes. May not be repeated for credit
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Students in a Non-Degree Undergraduate degree may **not** enroll.
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674/SYST 674 Dynamic Programming (3:3:0)
Prerequisites: OR 442 or OR 542 or permission of instructor
Course on the theory and practice of dynamic programming, i.e. optimal sequential decision making over time in the presence of uncertainties. The course will stress intuition, the mathematical foundations being for the most part elementary. It will introduce the theory, applications (finance, engineering, and biology), and computational aspects of dynamic programming for deterministic and stochastic problems.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Students in a Non-Degree Undergraduate degree may **not** enroll.
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675/SYST 675 Reliability Analysis (3:3:0)
Prerequisite: STAT 544, 554, OR 542, or permission of instructor.
Introduction to component and system reliability, their relationship, and problems of inference. Topics include component lifetime distributions and hazard functions, parameter estimation and hypothesis testing, life testing, accelerated life testing, system structural functions, and system maintainability.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Students in a Non-Degree Undergraduate degree may **not** enroll.
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681/SYST 573 Decision and Risk Analysis (3:3:0)
Prerequisite: STAT 344
Study of analytic techniques for rational decision making that address uncertainty, conflicting objectives, and risk attitudes. Covers modeling uncertainty; rational decision-making principles; representing decision problems with value trees, decision trees, and influence diagrams; solving value hierarchies, decision trees, and influence diagrams; defining and calculating the value of information; incorporating risk attitudes into the analysis; and conducting sensitivity analysis. Note: Students may not receive credit for both SYST 473 and 573.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Students in a Non-Degree Undergraduate degree may **not** enroll.
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682/CSI 690/MATH 685 Computational Methods in Engineering and Statistics (3:3:0)
Prerequisites: MATH 203 and 213 or equivalent, and modern numerical methods and software.
Numerical methods have been developed to solve mathematical problems that lack explicit closed-form solutions or have solutions that are not amenable to computer calculations. Examples include solving differential equations or computation probabilities. Discusses numerical methods for such problems as regression, analysis of variance, nonlinear equations, differential and difference equations and nonlinear optimization. Applications in statistics and engineering are emphasized. Involves extensive computer use.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Students in a Non-Degree Undergraduate degree may **not** enroll.
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683/SYST 680/ECE 670 Principles of Command, Control, Communications, Computers, and Intelligence (C4I) (3:3:0)
Prerequisite: ECE 528, OR 542, or SYST 611; or equivalent.
Fundamental principles of C4I are developed from descriptive, theoretical, and quantitative perspectives. Principles and techniques applicable to wide range of civilian and military situations. Topics include C2

process; modeling and simulation for combat operations; detection, sensing, and tracking; data fusion and situation assessment; optimal decision making; methodologies and tools of C4I architectures; tools for modeling and evaluations of C4 systems such as queuing theory.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Students in a Non-Degree Undergraduate degree may **not** enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges

688/SYST 688 Financial Systems Engineering II: Derivative Products and Risk Management (3:3:0)
Prerequisites: OR/SYST 588 or permission of instructor.
Financial engineering is a cross-disciplinary field which relies on mathematical finance, numerical methods, and computer simulations to make trading, hedging, and investment decisions, as well as facilitating the risk management of those decisions. This course will focus on risk management for both market risk and credit risk. It will cover a broad range of derivatives products and hedging strategies with emphasis on how risks are managed in financial institutions.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

690 Optimization of Supply Chains (3:3:0)
Prerequisites: Mathematics through linear Algebra, and STAT 344.
Focuses on both supply chain optimization from an enterprise-wide perspective, and supply chain optimization from a business-to-business e-commerce concern. Concerned with optimizing the value of goods and services and assuring a reasonable return on such sales. Describes both heuristic and exact algorithms for scheduling, production, inventory management, logistics, and distribution. New software that enables such optimization is presented, as are manufacturing and service examples from the public and private sectors. New techniques to handle risk, quality of data, and robustness of solutions are presented. Students perform case studies using state-of-the-art software.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

699 Masters Project (3:3:0)
Prerequisites: 21 graduate credits in OR or SYST.
Capstone project course for MS/OR program. Key activity is completion of a major applied team project resulting in an acceptable technical report and oral briefing. Student should plan to take this course in the last semester of studies.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges

719/CSI 775 Graphical Models for Inference and Decision Making (3:3:0)
Prerequisite: STAT 652 or SYST, or permission of instructor.
Theory and methods for inference and decision making in environments characterized by uncertain information. Covers graphical probability and decision models. Studies approaches to representing knowledge about uncertain phenomena, and planning and acting under uncertainty. Topics include knowledge engineering, exact and approximate inference in graphical models, learning in graphical models, temporal reasoning, planning, and decision-making. Practical model-building experience provided. Students apply what they learn to a project of their own choosing .
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges

735/SYST 735 Advanced Stochastic Simulation (3:3:0)
Prerequisite: OR 635, or permission of instructor.

Special topics and recent developments in Monte Carlo simulation methodology for discrete-event stochastic systems. Contents vary; possible topics include statistical analysis of simulation output data, random number and random ariate generation, variance reduction techniques, sensitivity analysis and optimization of simulation models, distributed and parallel simulation, object-oriented simulation, and specialized applications.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges

741 Advanced Linear Programming (3:3:0)
Prerequisites: OR 541 and 641.
Recent developments in linear programming. Highlights advances in interior point methods and also addresses developments in the simplex method. Projective methods, affine methods, and path-following methods are examined, including Karmarkar's original work. Discusses relationships between these methods, and relationships to methods in nonlinear programming. Also discussed are advances in data structures and other implementation issues. Students test software and solve large-scale linear programs.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges

750 Advanced Topics in Operations Research (3:3:0)
Prerequisites: OR 541 or 542, and 600-level course that varies with content of course.
Special topics, applications, or recent developments in operations research. Contents vary and may include topics in optimization, stochastic methods, or decision support that are not covered in the standard OR curriculum. May be repeated for credit when topics are distinctly different.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges

751 Advanced Topics in Operations Research for Planning and Scheduling (3:3:0)
Prerequisite: OR 541.
Introduces combinatorial optimization problems in scheduling and logistics. Solution techniques for various classes of such problems are developed. Topics include deterministic and stochastic scheduling algorithms with applications in manufacturing and service sectors.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges

763/SYST 763 Research Methods in Systems Engineering and Information Technology (3:3:0)
Prerequisite: STAT 554, OR 542, or permission of instructor
Examines alternative paradigms of scientific research and their applicability to research in information technology. Topics include fundamental elements of scientific investigation, basic principles of experimental design and statistical induction, philosophy of science and its relation to the information technology sciences, and case studies of information technology research.
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus. Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges

774 Advanced Dynamic Programming (3:3:0)
Prerequisites: OR674/ SYST674 or permission of instructor
This course covers advanced topics on the theory and practice of dynamic programming, i.e. optimal sequential decision making over time in the presence of uncertainties. The course will stress on the mathematical foundations and will introduce the theory, computational aspect, and applications of dynamic programming for deterministic and stochastic problems.

Enrollment is limited to Graduate or Non-Degree level students. Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges

780 Queuing Modeling of Computer-Communication Networks (3:3:0)
Prerequisite: OR 645 or 647, or ECE 542; or equivalents.
Studies analytical modeling of computer and communication networks and performance evaluations. Topics include Markovian systems, open networks, closed networks, approximations, decomposition, simulation, sensitivity analysis, and optimal operation of systems. Presents local area networks, manufacturing systems, and other applications.
Enrollment is limited to Graduate or Non-Degree level students. Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges

782 Advanced Topics in Combinatorial Optimizations (3:3:0)
Prerequisites: OR 641 and 642.
Studies problems using most recent developments. Topics include cutting plane procedures based on polyhedral combinatorics; column-generation procedures for large, complex problems; heuristic approaches such as genetic algorithms, simulated annealing, and tabu search; study of special structures; reformulation techniques; and bounding approaches. Topics stress most recent developments in field. May be repeated for credit when topics are distinctly different.
Enrollment is limited to Graduate or Non-Degree level students. Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges

783 Advanced Topics in Network Optimization (3:3:0)
Prerequisite: OR 643.
Recent developments in solving optimization problems on networks. Prepares doctoral students to perform advanced research on network-related problems. Topics include linear, discrete, nonlinear, and stochastic problems. Several aspects of problems also studied, including computational complexity, exact algorithms, heuristics, solvable special cases, and computer implementation issues.
Enrollment is limited to Graduate or Non-Degree level students. Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges

784 Advanced Topics in Nonlinear Programming (3:3:0)
Prerequisite: OR 644.
Studies theory and algorithms for solving nonlinear optimization problems. Contents vary; possible topics include large-scale and parallel-unconstrained optimization, theoretical issues in constrained optimization, duality theory, Lagrangian and sequential quadratic programming methods. May be repeated for credit when topics are distinctly different.
Enrollment is limited to Graduate or Non-Degree level students. Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges

842/SYST 842 Models of Probabilistic Reasoning (3:3:0)
Prerequisites: STAT 544, OR 542, OR 681, or permission of instructor
Survey of alternative views about how incomplete, inconclusive, and possibly unreliable evidence might be evaluated and combined. Discusses Bayesian, Baconian, Shafer-Dempster, and Fuzzy systems for probabilistic reasoning.
Enrollment is limited to Graduate or Non-Degree level students.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges

888/SYST 888 Distributed Estimation and Multisensor Tracking and Fusion (3:3:0)

Prerequisite: ECE 734 or SYST 611.
Centralized and distributed estimation theory, hierarchical estimation, tracking and data association, multisensor multitarget tracking and fusion, distributed tracking in distributed sensor networks, track-to-track association and fusion, and Bayesian networks for fusion.
Enrollment is limited to Graduate.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges

944/SYST 944 The Process of Discovery and Its Enhancement in Engineering Applications (3:3:0)
Prerequisite: IT 842 or permission of instructor.
Studies ingredients of imaginative reasoning as it concerns efficient discovery of new ideas and valid evidential test of them. Topics include different interpretations of Peirce's theory of abductive reasoning and other forms of reasoning, Hintikka's analysis of process of inquiry, and current attempts to design systems that provide assistance in discovery-related or investigative activities.
Enrollment is limited to Graduate.
Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges

Systems Engineering and Operations Research (SEOR) Faculty

Adelman, Leonard, Ph.D., University of Colorado; Professor

Brouse, S. Peggy, Ph.D., George Mason University, Associate Professor

Chang, Kuo-Chu, Ph.D., University of Connecticut, Professor

Chen, Chun-Hung, Ph.D., Harvard University, Professor

Clemons, Thomas, Ph.D., George Mason University, Associate Professor

Costa, Paulo, Ph.D., George Mason University, Associate Professor

Donohue, George, Ph.D., Oklahoma State University, Professor Emeritus

El-Amine, Hadi, Ph.D., Virginia Tech, Assistant Professor

Ganesan, Rajesh, Ph.D., University of South Florida, Associate Professor

Hoffman, Karla L., Sc.D., The George Washington University; Professor

Huang, Chien-Chung, Ph.D., Georgia Institute of Technology, Assistant Professor

Ji, Ran, Ph.D., The George Washington University, Assistant Professor

Jones, Rochelle, Ph.D., University of Central Florida, Associate Professor

Laskey, Kathryn B., Ph.D., Carnegie Mellon University, Professor

Loerch, Andrew, Ph.D., Cornell University, Associate Professor

Nash, Stephen G., Ph.D., Stanford University, Professor

Pyster, Art, Ph.D., The Ohio State University, Professor

Sherry, Lance A., Ph.D., Arizona State University, Associate Professor

Shortle, John, Ph.D., University of California, Berkeley, Professor and Chair

Sokolov, Vadim, Ph.D., Northern Illinois University, Assistant Professor

Xu, Jie, Ph.D., Northwestern University, Associate Professor

Zaidi, Abbas, Ph.D., George Mason University, Professor

Adjunct Professors: Arab Ali; Michael Bailey; Philip Barry; Brian Burke; Steven Charbonneau; Kenneth Comer; Robert Edson; Larrie Ferreiro; Joshua Icore; Sabyasachi Guharay; Raza Hashim; Ilean Keltz; Howard Killam; Jack Laveson; Michael Mulhearn; Paul Nicholas; Jeffrey Ray; Martin Rothwell; Daniel Stimpson; Kathleen Warren; Fred Wieland; Ronald Woodaman;; Yue (Richard) Xie

Plan of Study (with no Concentration)

Master of Science in Operations Research

Name:_____ SID: _____

Address: _____

Phone/ email: _____

Degree Requirements (30) **Semester/Yr**

0. Foundation Course (if needed)

A. SYST 500: Quantitative Foundations for Systems Engineering (3) _____

I. Operations Research Core Courses (4)

A. OR 541: Deterministic Models (3) _____
B. OR 542: Stochastic Models (3) _____
C. OR 568: Applied Predictive Analytics (3) _____
D. OR 635: Discrete System Simulation (3) _____

II. Project Course (1)

OR 699: Masters Project (3) _____

III. Electives (5) - Students must complete at least **three** 600-level OR courses including one deterministic methods course and one stochastic methods course. At least two other elective courses must be taken from SEOR course offerings. The remaining course should be taken in an area appropriate to the student's interests.

Deterministic Methods Course: _____ _____
Stochastic Methods Course: _____ _____
OR 620-level or higher Course: _____ _____
Elective Course: _____ _____
Elective Course: _____ _____

Student Signature: _____ Date:_____

Faculty Advisor Signature: _____ Date: _____

Plan of Study (with Concentration)

Master of Science in Operations Research

Name:_____ SID: _____

Address: _____

Phone/ email: _____

Degree Requirements (30) **Semester/Yr**

0. Foundation Courses (if needed)

B. SYST 500: Quantitative Foundations for Systems Engineering (3) _____

I. Operations Research Core Courses (4)

A. OR 541: Deterministic Models (3) _____
B. OR 542: Stochastic Models (3) _____
C. OR 568: Applied Predictive Analytics (3) _____
D. OR 635: Discrete System Simulation (3) _____

II. Project Course (1)

OR 699: Masters Project (3) _____

III. Electives (5) – Students may construct concentration areas by choosing electives from among special groupings. The six concentrations available are data analytics, decision analysis, financial engineering, military operations research, optimization and stochastic modeling. **Please refer to the concentration area sections for the required courses in each concentration.**

Concentration area: _____

Required Course 1: _____ _____

Required Course 2: _____ _____

Required Course 3: _____ _____

Deterministic Course: _____ _____

Stochastic Course: _____ _____

Or Elective Course: _____ _____

(for OPT or STM concentrations)

Student Signature: _____ Date:_____

Faculty Advisor Signature: _____ Date: _____