

# OPERATIONS RESEARCH (OR)

## 300 Level Courses

**OR 335: *Discrete Systems Modeling and Simulation*.** 3 credits.

Introduces basic concepts of modeling complex discrete systems by computer simulation. Topics include Monte-Carlo methods, discrete-event modeling, specialized simulation software, and statistics of input and output analysis. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). Limited to two attempts. Equivalent to SYST 335.

**Registration Restrictions:**

**Required Prerequisites:** (SYST 130<sup>C</sup>, 130<sup>XS</sup>, CDS 130<sup>C</sup>, 130<sup>XS</sup>, CS 112<sup>C</sup>, 112<sup>XS</sup> or ENGR 125T) and (STAT 334<sup>C</sup>, 334<sup>XS</sup>, 344<sup>C</sup>, 344<sup>XS</sup>, 346<sup>C</sup>, 346<sup>XS</sup>, MATH 351<sup>C</sup> or 351<sup>XS</sup>) and (SYST 230<sup>\*C</sup>, 230<sup>XS</sup>, CS 211<sup>\*C</sup> or 211<sup>XS</sup>).

\* May be taken concurrently.

<sup>C</sup> Requires minimum grade of C.

<sup>XS</sup> Requires minimum grade of XS.

Students cannot enroll who have a major in Exploratory, Undecided or Undeclared.

Students with the terminated from CEC major attribute may **not** enroll.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Undergraduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

## 400 Level Courses

**OR 438: *Analytics for Financial Engineering and Econometrics*.** 3 credits.

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, pricing models, and risk analysis. Provides a foundation of basic theory and methodology as well as applied examples with techniques to analyzing large financial and econometric data. Hands-on experiments with R will be emphasized throughout the course. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). Limited to two attempts. Equivalent to SYST 438.

**Recommended Corequisite:** STAT 354

**Registration Restrictions:**

**Required Prerequisites:** (STAT 250<sup>C</sup> or 250<sup>XS</sup>) or (STAT 260<sup>C</sup> or 260<sup>XS</sup>) or (STAT 334<sup>C</sup> or 334<sup>XS</sup>) or (STAT 344<sup>C</sup> or 344<sup>XS</sup>) or (STAT 346<sup>C</sup> or 346<sup>XS</sup>) or (MATH 351<sup>C</sup> or 351<sup>XS</sup>).

<sup>C</sup> Requires minimum grade of C.

<sup>XS</sup> Requires minimum grade of XS.

Students with the terminated from CEC major attribute may **not** enroll.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Undergraduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 441: *Deterministic Optimization*.** 3 credits.

Survey of deterministic methods for solving real-world decision problems. Covers linear programming model and simplex method of solution,

duality, and sensitivity analysis; transportation and assignment problems; shortest path and maximal flow problems; and introduction to integer and nonlinear programming. Emphasizes modeling and problem solving.

Notes: Accelerated MS students may not receive credit for both OR/MATH 441 and OR 531 Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). Limited to two attempts. Equivalent to MATH 441.

**Registration Restrictions:**

**Required Prerequisites:** MATH 203<sup>C</sup> or 203<sup>XS</sup>.

<sup>C</sup> Requires minimum grade of C.

<sup>XS</sup> Requires minimum grade of XS.

Students cannot enroll who have a major in Exploratory, Undecided or Undeclared.

Students with the terminated from CEC major attribute may **not** enroll.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Undergraduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 442: *Stochastic Models*.** 3 credits.

Survey of probabilistic methods for solving decision problems under uncertainty, probability review, decision theory, queuing theory, inventory models, forecasting, Markov chain models, and simulation are covered. Emphasis on modeling and problem solving. Offered by Systems Engr & Operations Rsch. Equivalent to MATH 442. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). Limited to two attempts. Equivalent to MATH 442.

**Registration Restrictions:**

**Required Prerequisites:** STAT 334<sup>C</sup>, 334<sup>XS</sup>, 344<sup>XS</sup>, 344<sup>C</sup>, 346<sup>C</sup>, 346<sup>XS</sup>, MATH 351<sup>C</sup> or 351<sup>XS</sup>.

<sup>C</sup> Requires minimum grade of C.

<sup>XS</sup> Requires minimum grade of XS.

Students cannot enroll who have a major in Exploratory, Undecided or Undeclared.

Students with the terminated from CEC major attribute may **not** enroll.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Undergraduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 481: *Numerical Methods in Engineering*.** 3 credits.

Modern numerical methods and software. Emphasis on problem solving through software and assessing the quality of solutions obtained. Topics include computer arithmetic, linear equations and least squares data fitting, interpolation, nonlinear optimization, and differential equations. Involves extensive computer use. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). Limited to two attempts. Equivalent to MATH 446.

**Registration Restrictions:**

**Required Prerequisites:** (MATH 203<sup>C</sup> or 203<sup>XS</sup>) and (CS 112<sup>C</sup>, 112<sup>XS</sup>, SYST 130<sup>C</sup>, 130<sup>XS</sup>, CDS 130<sup>C</sup>, 130<sup>XS</sup> or ENGR 125T).

<sup>C</sup> Requires minimum grade of C.

<sup>XS</sup> Requires minimum grade of XS.

Students with the terminated from CEC major attribute may **not** enroll.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Undergraduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 498: *Independent Study in Operations Research*.** 1-3 credits.

Directed self-study of special topics of current interest in operations research. Notes: May be repeated if topics substantially different. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). Limited to two attempts.

**Recommended Prerequisite:** 60 hours; must be arranged with an instructor and approved by the dept. chair before registering.

**Registration Restrictions:**

Students with the terminated from CEC major attribute may **not** enroll.

**Schedule Type:** Independent Study

**Grading:**

This course is graded on the Undergraduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

## 500 Level Courses

**OR 531: *Introduction to Analytics and Modeling*.** 3 credits.

Course focus is predominantly on prescriptive analytics with some parts focused on predictive analytics. Topics include operations research techniques and their application to decision making such as mathematical optimization, networks modeling, stochastic modeling, and multi-objective modeling. Other topics such as Monte Carlo simulation, decision analysis using decision trees and quantitative value functions, and heuristic methods for non-smooth models are covered, as well as use of contemporary computer software for problem solving. In particular, the course will use MS Excel extensively for building decision making support models. Case-study approach to problem solving is used. Notes: Cannot be used for credit for the PhD IT program. Offered by Systems Engr & Operations Research. May not be repeated for credit. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit.

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science or Engineering Computing colleges.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 538: *Analytics for Financial Engineering and Econometrics*.** 3 credits.

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, pricing models, and risk analysis. Provides a foundation of basic theory and methodology as well as applied examples with techniques to analyzing large financial and econometric data. Hands-on experiments with R will be emphasized throughout the course. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit. Equivalent to SYST 538.

**Recommended Prerequisite:** STAT 515 or STAT 544.

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science or Engineering Computing colleges.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 541: *Operations Research: Deterministic Optimization*.** 3 credits.

Survey of deterministic optimization 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. Notes: Students who have taken OR 441/MATH 441 will not receive credit. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit.

**Recommended Prerequisite:** MATH 203 or equivalent.

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science or Engineering Computing colleges.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 542: *Operations Research: Stochastic Models*.** 3 credits.

A survey of probabilistic methods for solving decision problems under uncertainty, probability theory review, forecasting, queuing theory,

inventory systems, Markov chain models, and simulation. Emphasis on modeling and problem solving. Notes: Students who have taken OR 442/ MATH 442 do not receive credit. Offered by Systems Engr & Operations Rsch. May not be repeated for credit. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit.

**Recommended Prerequisite:** STAT 344 or MATH 351 or equivalent.

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science or Engineering Computing colleges.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 568: *Applied Predictive Analytics*. 3 credits.**

Introduces predictive analytics and machine learning with applications in engineering, business, and econometrics. Topics include data preprocessing, predictive analytics with various machine learning models (e.g., linear, logistic regression, tree-based methods, SVM, neural networks, etc.) for regression and classification, time series analysis, and case studies. Provides a foundation of basic theory and methodology with applied examples to analyze large engineering, business, and econometric data for predictive decision making. Hands-on experiments with R will be emphasized. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit. Equivalent to SYST 568.

**Recommended Prerequisite:** STAT 515 or Graduate Standing at the MSOR or MSE programs.

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science or Engineering Computing colleges.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 574: *Quality Control and Process Management*. 3 credits.**

An overview of quality control techniques widely used in a number of manufacturing industries. The course teaches students about combining engineering process quality management and traditional statistical quality control procedures that are applicable in industry and are based

on contemporary technologies such as lean Six Sigma, total quality management and predictive maintenance for achieving superior quality, reliability and maintainability. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit. Equivalent to SYST 574.

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science or Engineering Computing colleges.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 576: *Manufacturing Systems Analysis*. 3 credits.**

An overview of modeling and analysis of general manufacturing systems techniques widely used in a number of manufacturing industries, such as semiconductor manufacturing. The course teaches students about best scheduling and inventory control practices, enterprise resource management principles, and details of engineering economy that are applicable in the industry. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit. Equivalent to SYST 576.

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science or Engineering Computing colleges.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 584: *Heterogeneous Data Fusion*. 3 credits.**

Introduces the theory, design and implementation of multi-source information fusion systems in various domains. The course covers distinct technologies for combining data from multiple, heterogeneous sources and performing inferences in support to applications such as cyber security, Semantic Web, decision support systems, situational awareness, intrusion detection, crisis management, and others. The technical content is largely multi-disciplinary, encompassing disciplines such as knowledge engineering, ontologies, statistical learning, artificial intelligence, and data mining. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit. Equivalent to SYST 584.

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science or Engineering Computing colleges.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 588:** *Financial Systems Engineering I: Introduction to Options, Futures, and Derivatives*. 3 credits.

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 valuation model. Numerical methods for option pricing, such as Binomial tree and Monte Carlo simulation will also be covered. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit. Equivalent to SYST 588.

**Recommended Prerequisite:** Eng. or Math Graduate standing, or permission of instructor.

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science or Engineering Computing colleges.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**600 Level Courses**

**OR 603:** *Sports Analytics*. 3 credits.

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. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/>)

<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit.

**Recommended Prerequisite:** (OR 531 or OR 541), and (STAT 518 or OR 568).

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science or Engineering Computing colleges.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 604:** *Data-driven Large-scale Optimization*. 3 credits.

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. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit.

**Recommended Prerequisite:** OR 531 and CS 504 or higher programming course.

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science or Engineering Computing colleges.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 610:** *Deep Learning for Predictive Analytics*. 3 credits.

Overview of the theoretical and algorithmic foundations of deep learning as well as practical aspects of developing deep learning predictive models. Topics include theoretical results from convex optimization and approximation theories, first and second order optimization algorithms (stochastic gradient descent, Nesterov acceleration, Newton's), overview of popular architectures (recurrent and convolutional networks), accelerated linear algebra, GPU computing, automated differentiation and Bayesian inference. Applications in engineering, finance and artificial intelligence. Practical aspects of building predictive models, such as architecture selection, and data normalization. Extensive use of computational tools, such as the Python language, both for illustration

in class and in homework problems. In addition to traditional instruction, a number of case studies and students' model building projects provide further breadth and exposure. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit.

**Recommended Prerequisite:** (OR 541 or OR 604) and (OR 568 or OR 664), or permission of instructor

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Students in a Non-Degree Undergraduate degree may **not** enroll.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 635: Discrete System Simulation.** 3 credits.

Computer simulation as a scientific methodology in operations analytics, with emphasis on model development, implementation, and analysis of results. Discrete-event models, specialized software and programming, input modeling, random variate generation, output statistical analysis, design of simulation experiments, and simulation-based optimization are covered. Extensive computational work is required. Offered by Systems Engr & Operations Rsch. May not be repeated for credit. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit.

**Recommended Prerequisite:** OR 542, or STAT 354 or 344, or equivalent; and knowledge of scientific programming language.

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science or Engineering Computing colleges.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 638: Machine Learning for Financial Engineering.** 3 credits.

This course focuses on the intersection of machine learning (ML) and financial engineering. It will introduce both supervised and unsupervised learning techniques and their applications to key areas in finance, including risk management, algorithmic trading, and portfolio optimization. Special attention is given to the use of neural networks, deep learning, and reinforcement learning to solve complex financial problems, bridging the gap between predictive analytics and economic theory. Through a combination of theoretical discussions and hands-on practical projects, students will learn to leverage ML algorithms for data-driven decision-making in finance, equipping them with the skills to innovate and excel in the fast-evolving financial industry. Offered by

Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit. Equivalent to SYST 638.

**Registration Restrictions:**

**Required Prerequisites:** OR 438<sup>B-</sup> or 538<sup>B-</sup>.

<sup>B-</sup> Requires minimum grade of B-

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Students in a Non-Degree Undergraduate degree may **not** enroll.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 640: Global Optimization and Computational Intelligence.** 3 credits.

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. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit.

**Recommended Prerequisite:** MATH 203 or equivalent, and knowledge of a scientific programming language.

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science or Engineering Computing colleges.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 641: Linear Programming.** 3 credits.

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. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit.

**Recommended Prerequisite:** OR 541 or permission of instructor.

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science or Engineering Computing colleges.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 642: Integer Programming.** 3 credits.

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. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit.

**Recommended Prerequisite:** OR 541 or permission of instructor.

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science or Engineering Computing colleges.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 643: Network Modeling.** 3 credits.

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. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit.

**Recommended Prerequisite:** OR 541 or permission of instructor.

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science or Engineering Computing colleges.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 644: Nonlinear Programming.** 3 credits.

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. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit.

**Recommended Prerequisite:** MATH 213 or equivalent and OR 541 or permission of instructor.

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science or Engineering Computing colleges.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 645: Stochastic Processes.** 3 credits.

Selected applied probability models including Poisson processes, discrete- and continuous-time Markov chains, renewal and regenerative processes, semi-Markov processes, queuing and inventory systems, and reliability theory. Emphasis on applications in practice as well as analytical models. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit.

**Recommended Prerequisite:** OR 542 or STAT 544 or permission of instructor.

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science or Engineering Computing colleges.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 646: Stochastic Optimization.** 3 credits.

Provides an introduction to stochastic optimization, more specifically, stochastic programming. The objectives are (i) to provide students with the ability to model and solve optimization problems under uncertainty, and (ii) to make students familiar with the state-of-the-art of stochastic programming. Homework will be used to reinforce and supplement information in each section. Through the semester we will be reading research papers to supplement the material in the text book. Papers and other course material will be provided on Blackboard. Students should be proficient with one programming language (e.g. MATLAB, Python, Java, C++) and should be able to become familiar with a math programming solver (e.g. Cplex, Gurobi.) Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit.

**Recommended Prerequisite:** OR 541 and OR 542.

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science or Engineering Computing colleges.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 647: Queuing Theory.** 3 credits.

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. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit.

**Recommended Prerequisite:** OR 542, STAT 544, or permission of instructor.

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science or Engineering Computing colleges.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 649: Topics in Operations Research.** 3-6 credits.

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. Notes: May be repeated if topics substantially different. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May be repeated within the term.

**Specialized Designation:** Topic Varies

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science or Engineering Computing colleges.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 651: Military Operations Research I: Cost Analysis.** 3 credits.

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. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit.

**Recommended Corequisite:** OR 541 or OR 542.

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science or Engineering Computing colleges.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 652: *Military Operations Research Modeling II: Effectiveness Analysis*.** 3 credits.

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. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit.

**Recommended Corequisite:** OR 541 or OR 542.

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science or Engineering Computing colleges.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 660: *Air Transportation Systems Modeling*.** 3 credits.

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. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit. Equivalent to SYST 660.

**Recommended Prerequisite:** SYST 460/560, or permission of instructor.

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science or Engineering Computing colleges.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 664: *Bayesian Artificial Intelligence*.** 3 credits.

Many artificial intelligence problems involve modeling uncertainty. Bayesian probabilistic models represent uncertainty and dependencies between random variables using probability distributions. You will learn the set of rules of probability and computational algorithms to manipulate these distributions. Bayesian approach enhances the effectiveness of conventional AI techniques. This course summarizes various Bayesian-based models and the standard algorithms used with them, supplemented by instances of their practical use. We will discuss applications in science, engineering, economics, medicine, sport, and law. Students will learn the commonalities and differences between the Bayesian and frequentist approaches to statistical inference, how to approach a statistics problem from the Bayesian perspective, and how to combine data with informed expert judgment soundly to derive useful and policy-relevant conclusions. Assignments focus on applying the methods to practical problems. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit. Equivalent to CSI 674, SYST 664.

**Recommended Prerequisite:** STAT 544, STAT 554, or equivalent.

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science or Engineering Computing colleges.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 670: *Metaheuristics for Optimization*.** 3 credits.

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. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit. Equivalent to SYST 670.

**Recommended Prerequisite:** OR 441/541 or permission of instructor.

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.



Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science or Engineering Computing colleges.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 674: *Dynamic Programming*. 3 credits.**

Course on the theory and practice of dynamic programming, i.e., optimal sequential decision making over time in the presence of uncertainties. Stresses intuition, the mathematical foundations being for the most part elementary. Introduces the theory, applications in finance and engineering, and computational aspects of dynamic programming for deterministic and stochastic problems. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit. Equivalent to SYST 674.

**Recommended Prerequisite:** OR 442 or OR 542 or permission of instructor.

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science or Engineering Computing colleges.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 675: *Reliability Analysis*. 3 credits.**

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. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit. Equivalent to SYST 675.

**Recommended Prerequisite:** STAT 544/554, OR 542 or permission of instructor.

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science or Engineering Computing colleges.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 681: *Decision and Risk Analysis*. 3 credits.**

Application of analytic reasoning and skills to practical problems in decision-making. Topics include problem structure, analysis and solution implementation, emphasizing contemporary approaches to decision analytic techniques. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit. Equivalent to SYST 573.

**Recommended Prerequisite:** OR 542 or MBA 638.

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science or Engineering Computing colleges.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 682: *Computational Methods in Engineering and Statistics*. 3 credits.**

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. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit. Equivalent to CSI 690, MATH 685.

**Recommended Prerequisite:** MATH 203 and 213 or equivalent, and modern numerical methods and software.

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science or Engineering Computing colleges.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 683:** *Principles of Command, Control, Communications, Computing, and Intelligence (C4I)*. 3 credits.

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. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit.

**Recommended Prerequisite:** ECE 528 or OR 542 or SYST 611 or equivalent.

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science or Engineering Computing colleges.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 688:** *Financial Systems Engineering II: Derivative Products and Risk Management*. 3 credits.

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 introduce basic concepts of options, futures, and financial derivatives markets. It will focus on risk management for market risk, credit risk, and operational risk. It will also cover a broad range of derivatives products and discuss how risks are managed in financial institutions. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit. Equivalent to SYST 688.

**Recommended Prerequisite:** OR 588 or SYST 588 or permission of instructor.

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science or Engineering Computing colleges.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 690:** *Optimization of Supply Chains*. 3 credits.

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. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit.

**Recommended Prerequisite:** Mathematics through linear algebra, and STAT 344.

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science or Engineering Computing colleges.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 699:** *Masters Project*. 3 credits.

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. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit.

**Recommended Prerequisite:** 21 graduate credits in OR or SYST.

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science or Engineering Computing colleges.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

## 700 Level Courses

**OR 719: *Graphical Models for Inference and Decision Making*.** 3 credits.  
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. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit. Equivalent to CSI 775.

**Recommended Prerequisite:** STAT 652 or permission of instructor.

### Registration Restrictions:

Enrollment is limited to Graduate or Non-Degree level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

**Schedule Type:** Lecture

### Grading:

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 735: *Simulation and Artificial Intelligence*.** 3 credits.

Advanced topics and recent developments in stochastic simulation methodology and the intersection with artificial intelligence, featuring interdisciplinary applications in energy systems, financial engineering, health care, manufacturing, transportation, etc. Topics include simulation multivariate input modeling and uncertainty quantification, surrogate modeling with Gaussian process, simulation experiment design, simulation risk analytics, simulation optimization, digital twin-based decision making, optimal sampling policies for reinforcement learning, Monte Carlo tree search, and active learning. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit. Equivalent to SYST 735.

**Recommended Prerequisite:** OR 635 or permission of instructor.

### Registration Restrictions:

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 Engineering Computing colleges.

**Schedule Type:** Lecture

### Grading:

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 741: *Advanced Linear Programming*.** 3 credits.

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. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit.

**Recommended Prerequisite:** OR 541 or 641.

### Registration Restrictions:

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 Engineering Computing colleges.

**Schedule Type:** Lecture

### Grading:

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 750: *Advanced Topics in Operations Research*.** 3 credits.

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. Notes: May be repeated when topics are distinctly different. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May be repeated within the term for a maximum 12 credits.

**Specialized Designation:** Topic Varies

**Recommended Prerequisite:** OR 541 or 542, and 600-level course that varies with content of course.

### Registration Restrictions:

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 Engineering Computing colleges.

**Schedule Type:** Lecture

### Grading:

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 751: *Advanced Topics in Operations Research for Planning and Scheduling*.** 3 credits.

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. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit.

**Specialized Designation:** Topic Varies

**Recommended Prerequisite:** OR 541.

### Registration Restrictions:

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 Engineering Computing colleges.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 763: *Research Methods in Systems Engineering and Information Technology*.** 3 credits.

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. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit. Equivalent to SYST 763.

**Recommended Prerequisite:** STAT 554, OR 542, or permission of instructor.

**Registration Restrictions:**

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 Engineering Computing colleges.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 774: *Reinforcement Learning*.** 3 credits.

Covers advanced topics on the theory and practice of reinforcement learning and dynamic programming, i.e., optimal sequential decision making over time in the presence of uncertainties. Stresses the mathematical foundations and introduces the theory, computational aspect, and applications of reinforcement learning and approximate dynamic programming for large-scale stochastic problems. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit.

**Recommended Prerequisite:** OR 674/SYST 674 or permission of instructor.

**Registration Restrictions:**

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 Engineering Computing colleges.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 782: *Advanced Topics in Combinatorial Optimizations*.** 3 credits.

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. Notes: May be repeated when topics are distinctly different. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May be repeated within the degree for a maximum 6 credits.

**Specialized Designation:** Topic Varies

**Recommended Prerequisite:** OR 641 or OR 642.

**Registration Restrictions:**

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 Engineering Computing colleges.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 783: *Advanced Topics in Network Optimization*.** 3 credits.

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. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May be repeated within the degree for a maximum 6 credits.

**Specialized Designation:** Topic Varies

**Recommended Prerequisite:** OR 643.

**Registration Restrictions:**

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 Engineering Computing colleges.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 784: *Advanced Topics in Nonlinear Programming*.** 3 credits.

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. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit.

**Specialized Designation:** Topic Varies

**Recommended Prerequisite:** OR 644.

**Registration Restrictions:**

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 Engineering Computing colleges.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

**OR 799: *Master's Thesis.*** 1-6 credits.

Research project chosen and completed under the guidance of a graduate faculty member, which results in a technical report acceptable to a three-member faculty committee, and an oral defense. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May be repeated within the degree.

**Recommended Prerequisite:** 21 graduate credits and permission of instructor.

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy or Graduate.

Students in a Non-Degree Undergraduate degree may **not** enroll.

**Schedule Type:** Thesis

**Grading:**

This course is graded on the Satisfactory/No Credit scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

## 800 Level Courses

**OR 842: *Models of Probabilistic Reasoning.*** 3 credits.

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. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit.

**Recommended Prerequisite:** STAT 544, OR 542, OR 681 or permission of instructor.

**Registration Restrictions:**

Enrollment is limited to Graduate level students.

Enrollment limited to students in the College of Science or Engineering Computing colleges.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)

## 900 Level Courses

**OR 944: *The Process of Discovery and Its Enhancement in Engineering Applications.*** 3 credits.

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. Offered by Systems Engr & Operations Rsch (<http://catalog.gmu.edu/colleges-schools/engineering-computing/engineering/systems-operations-research/>). May not be repeated for credit. Equivalent to SYST 944.

**Recommended Prerequisite:** OR 842 or SYST 842 or permission of instructor.

**Registration Restrictions:**

Enrollment is limited to Graduate level students.

Enrollment limited to students in the College of Science or Engineering Computing colleges.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<http://catalog.gmu.edu/policies/academic/grading/>)