Operations Research (OR)

OR 425/OR 525/ISE 525/ISE 425 Medical Decision Making (3 credit hours)
This will focus on the use of optimization in Medicine. The main goal of this course is for you to develop an understanding of the recent methodological literature on optimization methods applied to medical decision making. We will cover a broad range of topics, both from the methodological perspective (study models using integer programming, dynamic programming, simulation, etc.) and from the public policy/public health perspective (who are the stake holders, what are the relevant questions modelers can answer, how is the patient taken into account, etc.).

P: ISE/OR 505 or equivalent and ISE 560 or equivalent or permission by instructor
Typically offered in Spring only

OR 433/OR 533/ISE 433/ISE 533 Service Systems Engineering (3 credit hours)
This course intends to provide a comprehensive treatment on the use of quantitative modeling for decision making and best practices in the service industries. The goal of this class is to teach students to able to identify, understand, and analyze services; and acquire the quantitative skills necessary to model key decisions and performance metrics associated with services. Students will be exposed both to classical and contemporary examples of challenges and opportunities that arise when working in the service sector.

Prerequisite: ISE 361
Typically offered in Spring only

OR 501/ISE 501 Introduction to Operations Research (3 credit hours)
Operations Research (OR) is a discipline that involves the development and application of advanced analytical methods to aid complex decisions. This course will provide students with the skills to be able to apply a variety of analytical methods to a diverse set of applications. Methods considered include linear and mixed-integer programming, nonlinear and combinatorial optimization, network models, and machine learning. Focus will be on how to translate real-world problems into appropriate models and then how to apply computational procedures and data so that the models can be used as aids in making decisions. Applications will include improving the operation of a variety of different production and service systems, including healthcare delivery and transportation systems, and also how OR can be used to make better decisions in areas like sports, marketing, and project management. Prerequisites include undergraduate courses in single variable differential and integral calculus and an introductory course in probability.

Prerequisites include undergraduate courses in single variable differential and integral calculus (similar to MA 421) and an introductory course in probability (similar to ST 421 or ST 371 and ST 372)
Typically offered in Fall, Spring, and Summer

OR 504/MA 504 Introduction to Mathematical Programming (3 credit hours)
Basic concepts of linear, nonlinear and dynamic programming theory. Not for majors in OR at Ph.D. level.

Prerequisite: MA 242, MA 405
Typically offered in Fall only

OR 505/ISE 505/MA 505 Linear Programming (3 credit hours)
Introduction including: applications to economics and engineering; the simplex and interior-point methods; parametric programming and post-optimality analysis; duality matrix games, linear systems solvability theory and linear systems duality theory; polyhedral sets and cones, including their convexity and separation properties and dual representations; equilibrium prices, Lagrange multipliers, subgradients and sensitivity analysis.

Prerequisite: MA 405
Typically offered in Fall only

OR 506 Algorithmic Methods in Nonlinear Programming (3 credit hours)
Introduction to methods for obtaining approximate solutions to unconstrained and constrained minimization problems of moderate size. Emphasis on geometrical interpretation and actual coordinate descent, steepest descent, Newton and quasi-Newton methods, conjugate gradient search, gradient projection and penalty function methods for constrained problems. Specialized problems and algorithms treated as time permits.

Prerequisite: Linear algebra or similar coursework (similar to MA 303, MA 405), and knowledge of a computer language, such as Python, MATLAB, Julia, for example.
Typically offered in Fall only

OR 525/ISE 525/ISE 425/OR 425 Medical Decision Making (3 credit hours)
This will focus on the use of optimization in Medicine. The main goal of this course is for you to develop an understanding of the recent methodological literature on optimization methods applied to medical decision making. We will cover a broad range of topics, both from the methodological perspective (study models using integer programming, dynamic programming, simulation, etc.) and from the public policy/public health perspective (who are the stake holders, what are the relevant questions modelers can answer, how is the patient taken into account, etc.).

P: ISE/OR 505 or equivalent and ISE 560 or equivalent or permission by instructor
Typically offered in Spring only

OR 531/MA 531/E 531 Dynamic Systems and Multivariable Control I (3 credit hours)
Introduction to modeling, analysis and control of linear discrete-time and continuous-time dynamical systems. State space representations and transfer methods. Controllability and observability. Realization. Applications to biological, chemical, economic, electrical, mechanical and sociological systems.

Prerequisite: MA 341, MA 405
Typically offered in Fall only

OR 533/ISE 433/ISE 533/OR 433 Service Systems Engineering (3 credit hours)
This course intends to provide a comprehensive treatment on the use of quantitative modeling for decision making and best practices in the service industries. The goal of this class is to teach students to able to identify, understand, and analyze services; and acquire the quantitative skills necessary to model key decisions and performance metrics associated with services. Students will be exposed both to classical and contemporary examples of challenges and opportunities that arise when working in the service sector.

Prerequisite: ISE 361
Typically offered in Spring only

OR 537/CE 537 Computer Methods and Applications (3 credit hours)
Computational approaches to support civil planning, analysis, evaluation and design. Applications to various areas of civil engineering, including construction, structures, transportation and water resources.

Prerequisite: CSC 112 and (MA 341 or MA 305)
Typically offered in Fall only

OR 547/TE 547 Introduction to System Reliability Engineering (3 credit hours)
Quantitative methods of measuring the reliability of complex engineering systems, including statistical analysis, stochastic process, and optimization theory. Emphasis on solving real-world problems through hands-on experience from class projects.

Prerequisite: ST 370 and ST 421 and ST 501 and ST 511 and ST 515 or equivalent
Typically offered in Fall and Spring

OR 560/ISE 560 Stochastic Models in Industrial Engineering (3 credit hours)
ISE/OR 560 will introduce mathematical modeling, analysis, and solution procedures applicable to uncertain (stochastic) production and service systems. Methodologies covered include probability theory and stochastic processes including discrete and continuous Markov processes. Applications relate to design and analysis of problems, capacity planning, inventory control, waiting lines, and service systems.

Typically offered in Fall only

OR 562/ISE 562/TE 562 Simulation Modeling (3 credit hours)
This course concentrates on design, construction, and use of discrete/continuous simulation object-based models employing the SIMIO software, with application to manufacturing, service, and healthcare. The focus is on methods for modeling and analyzing complex problems using simulation objects. Analysis includes data-based modeling, process design, input modeling, output analysis, and the use of 3D animation with other graphical displays. Object-oriented modeling is used to extend models and enhance re-usability.

Typically offered in Spring only

OR 565/CSC 565/MA 565 Graph Theory (3 credit hours)
Basic concepts of graph theory. Trees and forests. Vector spaces associated with a graph. Representation of graphs by binary matrices and list structures. Traversability. Connectivity. Matchings and assignment problems. Planar graphs. Colorability. Directed graphs. Applications of graph theory with emphasis on organizing problems in a form suitable for computer solution.

Prerequisite: CSC 226 or MA 351.
Typically offered in Spring only

OR 579/CSC 579/ECE 579 Introduction to Computer Performance Modeling (3 credit hours)
Workload characterization, collection and analysis of performance data, instrumentation, tuning, analytic models including queuing network models and operational analysis, economic considerations.

Prerequisite: CSC 312 or ECE 206 and MA 421
Typically offered in Fall and Spring

OR 591 Special Topics in Operations Research (1-6 credit hours)
Individual or small group studies of special areas of OR which fit into students' programs of study and which may not be covered by other OR courses. Furthermore, course serves as a vehicle for introducing new or specialized topics at introductory graduate level.

Typically offered in Fall, Spring, and Summer

OR 601 Seminar in Operations Research (1 credit hours)
Seminar discussion of operations research problems. Case analyses and reports. Graduate students with minors or majors in operations research expected to attend throughout period of their residence.

Prerequisite: OR Major or OR Minor
Typically offered in Fall and Spring

OR 610 Special Topics in Operations Research (1-6 credit hours)
Individual or small group studies of special areas of OR which fit into students' programs of study and which may not be covered by other OR courses. Furthermore, course serves as a vehicle for introducing new or specialized topics at introductory graduate level.

Typically offered in Fall, Spring, and Summer

OR 652 Practicum in Operations Research (1-3 credit hours)
Practicum in problem solving in industry applying applicable OR methodologies. Practical experience in diagnosing and solving problems in operational systems at either an industrial site or at NC State.

Prerequisite: OR 501, OR 505, OR 709 and OR 761
Typically offered in Summer only

OR 688 Non-Thesis Masters Continuous Registration - Half Time Registration (1 credit hours)
For students in non-thesis master's programs who have completed all credit hour requirements for their degree but need to maintain half-time continuous registration to complete incomplete grades, projects, final master's exam, etc.

Prerequisite: Master's student
Typically offered in Spring only

OR 689 Non-Thesis Master Continuous Registration - Full Time Registration (3 credit hours)
For students in non-thesis master's programs who have completed all credit hour requirements for their degree but need to maintain full-time continuous registration to complete incomplete grades, projects, final master's exam, etc. Students may register for this course a maximum of one semester.

Prerequisite: Master's student
Typically offered in Spring only

OR 690 Master's Examination (1-9 credit hours)
For students in non thesis master's programs who have completed all other requirements of the degree except preparing for and taking the final master's exam.

Prerequisite: Master's student
Typically offered in Summer only

OR 693 Master's Supervised Research (1-9 credit hours)
Instruction in research and research under the mentorship of a member of the Graduate Faculty.

Prerequisite: Master's student
Typically offered in Fall and Spring

OR 695 Master's Thesis Research (1-9 credit hours)
Thesis research.

Prerequisite: Master's student
Typically offered in Fall, Spring, and Summer

OR 696 Summer Thesis Research (1 credit hours)
For graduate students whose programs of work specify no formal course work during a summer session and who will be devoting full time to thesis research.

Prerequisite: Master's student
Typically offered in Summer only

OR 699 Master's Thesis Preparation (1-9 credit hours)
For student who have completed all credit hour requirements and full-time enrollment for the master's degree and are writing and defending their theses.

Prerequisite: Master's student
Typically offered in Fall, Spring, and Summer

OR 705 Large-Scale Linear Programming Systems (3 credit hours)
Specialized algorithms for efficient solution of large-scale LP problems. Parametric programming, bounded variable algorithms, generalized upper bounding, decomposition, matrix factorization and sparse matrix techniques. Emphasis on gaining firsthand practical experience with current computer codes and computational procedures.

Prerequisite: OR 505 and FORTRAN programming experience
Typically offered in Spring only

OR 706/ST 706/MA 706 Nonlinear Programming (3 credit hours)
An advanced mathematical treatment of analytical and algorithmic aspects of finite dimensional nonlinear programming. Including an examination of structure and effectiveness of computational methods for unconstrained and constrained minimization. Special attention directed toward current research and recent developments in the field.

Prerequisite: OR(IE,MA) 505 and MA 425
Typically offered in Spring only

OR 708/ISE 708/MA 708 Integer Programming (3 credit hours)
General integer programming problems and principal methods of solving them. Emphasis on intuitive presentation of ideas underlying various algorithms rather than detailed description of computer codes. Students have some "hands on" computing experience that should enable them to adapt ideas presented in course to integer programming problems they may encounter.

Prerequisite: MA 405, OR (MA,IE) 505, Corequisite: Some familiarity with computers (e.g., CSC 112)
Typically offered in Spring only

OR 709/ISE 709 Dynamic Programming (3 credit hours)
Introduction to theory and computational aspects of dynamic programming and its application to sequential decision problems.

Prerequisite: MA 405, ST 421
Typically offered in Spring only

OR 719/MA 719 Vector Space Methods in System Optimization (3 credit hours)
Introduction to algebraic and function-analytic concepts used in system modeling and optimization: vector space, linear mappings, spectral decomposition, adjoints, orthogonal projection, quality, fixed points and differentials. Emphasis on geometricinsight. Topics include least square optimization of linear systems, minimum norm problems in Banach space, linearization in Hilbert space, iterative solution of system equations and optimization problems. Broad range of applications in operations research and system engineering including control theory, mathematical programming, econometrics, statistical estimation, circuit theory and numerical analysis.

Prerequisite: MA 405, 511
Typically offered in Fall only

OR 731/E 731/MA 731 Dynamic Systems and Multivariable Control II (3 credit hours)
Stability of equilibrium points for nonlinear systems. Liapunov functions. Unconstrained and constrained optimal control problems. Pontryagin's maximum principle and dynamic programming. Computation with gradient methods and Newton methods. Multidisciplinary applications.

Prerequisite: OR(E,MA) 531
Typically offered in Spring only

OR 747/ISE 747 Reliability Engineering (3 credit hours)
Introduction to basic concepts of reliability engineering. Application of probability and statistics to estimate reliability of industrial systems; development of reliability measures; analysis of static and dynamic reliability models; development and analysis of fault trees; analysis of Markovian and non-Markovian models; and optimization of reliability models.

Prerequisite: ST 511
Typically offered in Fall only

OR 760/ISE 760 Applied Stochastic Models in Industrial Engineering (3 credit hours)
Formulation and analysis of stochastic models with particular emphasis on applications in industrial engineering; univariate, multivariate and conditional probability distributions; unconditional and conditional expectations; elements of stochastic processes; moment-generating functions; concepts of stochastic convergence; limit theorems; homogeneous, nonhomogeneous and compound Poisson processes; basic renewal theory; transient and steady-state properties of Markov processes in discrete and continuous time.

Prerequisite: MA 303, ST 371
Typically offered in Fall only

OR 761/ISE 761 Queues and Stochastic Service Systems (3 credit hours)
Introduction of general concepts of stochastic processes. Poisson processes, Markov processes and renewal theory. Usage of these in analysis of queues, from with a completely memoryless queue to one with general parameters. Applications to many engineering problems.

Typically offered in Spring only

OR 762/ISE 762/CSC 762 Stochastic Simulation (3 credit hours)
Basic discrete event simulation methodology: random number generators, generating random objects, design of discrete event simulation, validation, analysis of simulation output, variance reduction techniques, Markov chain Monte Carlo, simulation optimization. The course has computer assignments and projects. This course is a sequel to ISE/OR 760 Stochastic Models which serves as a prerequisite. This is NOT a software based course! Students who are looking for a class on simulation software, such as Arena and Simio, are recommended to take ISE 562 (master-level simulation class).

Students should have completed a course on stochastic models (similar to ISE 560 or ISE 760) and have a working knowledge of a programming language (e.g., Python, Matlab, R, or others).
Typically offered in Fall and Spring

OR 766/ISE 766/MA 766 Network Flows (3 credit hours)
Study of problems of flows in networks. These problems include the determination of shortest chain, maximal flow and minimal cost flow in networks. Relationship between network flows and linear programming developed as well as problems with nonlinear cost functions, multi-commodity flows and problem of network synthesis.

Prerequisite: OR(IE,MA) 505
Typically offered in Spring only

OR 772/ISE 772 Advanced Stochastic Simulation (3 credit hours)
This course is methodologically focused and a continuation of ISE 762 in Monte Carlo methods. The topics include, but are not limited to, Quasi-Monte Carlo, importance sampling and other advanced variance reduction approaches, derivative estimation, and advanced simulation optimization in continuous and finite spaces. While the application of these techniques to actual simulations is practiced as assignments, the discussion on simulation software and programming will be minimal. A current topic research presentation/paper required.

Prerequisite: (CSC,ECE,IE,OR) 762 and ST 516
Typically offered in Spring only

OR 773/ST 773/BMA 773/MA 773 Stochastic Modeling (3 credit hours)
Survey of modeling approaches and analysis methods for data from continuous state random processes. Emphasis on differential and difference equations with noisy input. Doob-Meyer decomposition of process into its signal and noise components. Examples from biological and physical sciences, and engineering. Student project.

Prerequisite: BMA 772 or ST (MA) 746
Typically offered in Spring only

OR 774/MA 774/BMA 774 Partial Differential Equation Modeling in Biology (3 credit hours)
Modeling with and analysis of partial differential equations as applied to real problems in biology. Review of diffusion and conservation laws. Waves and pattern formation. Chemotaxis and other forms of cell and organism movement. Introduction to solid and fluid mechanics/dynamics. Introductory numerical methods. Scaling. Perturbations, Asymptotics, Cartesian, polar and spherical geometries. Case studies.

Prerequisite: BMA 771 or MA/OR 731; BMA 772 or MA 401 or MA 501
Typically offered in Spring only

OR 791 Advanced Special Topics (1-6 credit hours)
Typically offered in Fall and Spring

OR 801 Seminar in Operations Research (1 credit hours)
Seminar discussion of operations research problems. Case analyses and reports. Graduate students with minors or majors in operations research expected to attend throughout period of their residence.

Prerequisite: OR Major or OR Minor
Typically offered in Fall and Spring

OR 810 Special Topics in Operations Research (1-6 credit hours)
Individual or small group studies of special areas of OR which fit into students' programs of study and which may not be covered by other OR courses. Furthermore, course serves as a vehicle for introducing new or specialized topics at introductory graduate level.

Typically offered in Fall, Spring, and Summer

OR 852 Practicum in Operations Research (1-3 credit hours)
Practicum in problem solving in industry applying applicable OR methodologies. Practical experience in diagnosing and solving problems in operational systems at either an industrial site or at NC State.

Prerequisite: OR 501, OR 505, OR 709 and OR 761
Typically offered in Summer only

OR 890 Doctoral Preliminary Examination (1-9 credit hours)
For students who are preparing for and taking written and/or oral preliminary exams.

Prerequisite: Doctoral student
Typically offered in Summer only

OR 893 Doctoral Supervised Research (1-9 credit hours)
Instruction in research and research under the mentorship of a member of the Graduate Faculty.

Prerequisite: Doctoral student
Typically offered in Fall and Spring

OR 895 Doctoral Dissertation Research (1-9 credit hours)
Dissertation research.

Prerequisite: Doctoral student
Typically offered in Fall, Spring, and Summer

OR 896 Summer Dissertation Research (1 credit hours)
For graduate students whose programs of work specify no formal course work during a summer session and who will be devoting full time to thesis research.

Prerequisite: Doctoral student
Typically offered in Summer only

OR 899 Doctoral Dissertation Preparation (1-9 credit hours)
For students who have completed all credit hour, full-time enrollment, preliminary examination, and residency requirements for the doctoral degree, and are writing and defending their dissertations.

Prerequisite: Doctoral student
Typically offered in Spring and Summer