RUTGERS

MBA/MS in Operations Research and Business Analytics (MBA-ORBA)
Rutgers Business School & Rutgers Graduate School of Arts and Sciences–New Brunswick

RUTGERS MBA/MS dual degree in Operations Research and Business Analytics (MBA-ORBA)

Summary

The dual MBA/MS degree in Operations Research and Business Analytics is a partnership between Rutgers Business School (RBS), the Rutgers Graduate School - New Brunswick Campus, and the Rutgers Center for Operations Research (RUTCOR).

The program integrates management, finance, accounting, operations and analytics. It is a sixty (60) credit dual-degree program composed of two complementary components.

The first component is the **Master of Business Administration** program at the Rutgers Business School. It allows the students who complete the Master of Operations Research program to also obtain the MBA degree by completing in addition the thirty (30) credit curriculum of the MBA required classes. It also allows the MBA students with a solid quantitative education to obtain the MSc degree by completing the Master of Operations Research curriculum, as a concentration.

The second component is the **Master of Operations Research** degree with a business analytics concentration. It intends to provide students who have a solid quantitative education (i.e., students with engineering, science, mathematics, economics or similar undergraduate education) with an MS degree that focuses on analytical skills and an understanding of how these are applied to business and management problems. It is a thirty (30) credit degree.

Students must complete the first component (MBA core) before they can start the second component (MS part)[*].

Motivation.

- There is a growing need across many fields for managers with both MBA skills and good quantitative training. Graduates of the **Rutgers dual MBA/MS in Operations Research and Business Analytics** degree possess an impressive assortment of analytical and problem-solving skills.

- The program's skills are in demand across a wide range of industries, including finance, pharmaceutical industry, and transportation. Graduates can expect to work in both technical and managerial capacities on development of projects for analyzing and acting on business data.

- The US BLS[†] forecasts that jobs in operations research will grow by 22 percent over the period 2008-2010, much faster than the average job growth. These jobs require Masters and PhD degrees. The greatest growth will be in the pharmaceutical manufacturing and the financial services industrial sectors – both sectors are clusters in the NYC metropolitan area.

- There will be a shortage of talent necessary for organizations to take advantage of big data. By 2018, the United States alone could face a shortage of 140,000 to 190,000 people with deep analytical

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[*] **This requirement does not apply to students already enrolled in the RUTCOR MS, for the 2011/2012 academic year.**

[†] http://www.bls.gov/oes/current/oes152031.htm

skills, as well as 1.5 million managers and analysts with the know-how to use the analysis of big data to make effective decisions.

Admission Requirements

The deadline for application to the program and for financial support for the Fall semester (beginning September) is January 15th. This deadline may be waived for qualified students, when this is possible. Applications for financial aid are accepted even into the summer months whenever support is still available. Foreign students, on the other hand, should be aware that the issue of I-20 and IAP-66 forms, that are needed to obtain a visa, can consume considerable time; they are advised to apply as soon as possible.

Prospective students should have aptitude for computers and quantitatively-oriented material. Applicants are expected to have a bachelor's degree and basic knowledge in calculus, statistics, and computer programming. We particularly welcome applicants with undergraduate degrees in engineering, computer science, mathematics, statistics, and related fields.

Part-time students with good credentials will be accepted. Students without an adequate background can take a number of undergraduate courses during their first year, and in some cases will be admitted to coursework only on a non-matriculated basis, with actual admission into the MBA-ORBA program depending on their performance.

Applications Process.

You will need the following:

- Essay on (1) of the 3 topics below.
    1. Describe an ethical dilemma.
    2. Discuss a team project that you were a part of that failed.
    3. Discuss (3) professional accomplishments that show you are a good manager.
- Official transcripts
- Resume, and
- Three(3) letters of recommendation
- Tests: Applicants should take either the GRE or the GMAT test. We prefer applicants with a minimum GRE score of 1100 (on the combined verbal and quantitative GREs) or a GMAT score of 650. However, admission to the program is based on an overall appraisal of the applicant such as recommendation letters, scores, grades, as well potential for success in our program. Foreign applicants are required to have a minimum TOEFL score of 110.
- Prospective students should apply to both programs separately at:
    - **https://apply.embark.com/MBAEdge/Rutgers/**
    - **https://admissionservices.rutgers.edu/graduate/newApplicant.app**
      use code :16:711 (Operations Research)

  and must be accepted by both program.

MBA/MS in Operations Research - Business Analytics

MBA Component

In this case the 30 credits of the Master in Operations Research program count towards the MBA degree. In addition, the students have to take the following courses:

Core MBA Courses (19 Credits)

- 22:010:502 Accounting for Managers
- 22:223:521 Managerial Economic Analysis
- 22:373:623 Business Ethics & Society (1 credit/5 weeks)
- 22:390:522 Financial Management
- 22:620:540 Organization Behavior
- 22:630:550 Marketing for Decision Making
- 22:799:564 Operations Analysis

Foundation MBA Courses (6 credits- each 2 credits unless noted)

- 22:198:504 Information Technology for Managers
- 22:373:510 Business Communications
- 22:373:531 Law and Legal Reasoning
- 22:553:533 International Business
- 22:620:542 Strategic Management
- 22:960:575 Data Analysis and Decision Making (3 cr)

Capstone MBA Course (1 Course; 3 credits)

- 22:621:543 Integrated Business Applications
- 22:620:672 Urban Entrepreneurship & Econ. Dev.
- 22:799:650 Supply Chain Mgt Industry Project

These courses are identical with the required part of the MBA curriculum at the Rutgers Business School (http://business.rutgers.edu/mba/full-time/flexible-curriculum/curriculum).

MBA/MS in Operations Research - Business Analytics

MS Component

Curriculum

The program curriculum has two main parts:

- Six required courses:
  - 16:711:614 Theory of Linear Optimization
  - 16:711:517 Computational Methods of Operations Research
  - 16:711:550 Nonlinear Optimization
  - 26:960:575 Introduction to Probability
  - 26:960:577 Introduction to Statistical Linear Models
  - 26:960:580 Stochastic Processes
- At least four of the following electives:
  - 16:711:465 Integer Programming
  - 16:711:555 Stochastic Programming
  - 16:711:557 Dynamic Programming
  - 16:711:613 Game Theory
  - 26:799:661 Stochastic Models for Supply Chain Management
  - 16:711:631 Financial Mathematics or 26:711:563 Stochastic Calculus for Finance
  - 26:960:576 Financial Time Series
  - 26:198:622 Machine Learning
  - 26:198:644 Data Mining or 16:711:514 Operations Research Approaches in Data Mining

Based on student’s record, a required course may be waived; in that case an elective course can be substituted, so that the total number of credits earned equals 30. Other electives may be substituted for the program’s electives, upon approval of the program’s director.

Brief MScCourse Descriptions

Required Courses

1. **16:711:614 Theory of Linear Optimization**. Convex sets, polyhedra, Farkas lemma, canonical forms, simplex algorithm, duality theory, revised simplex method, primal-dual methods, complementary slackness theorem, maximal flows, transportation problems, 2-person game theory. Students will have the chance to apply the methods to real life problems. One of the aims of the course will be to teach the students the path: from real life problem to abstraction, to mathematical formulation, to solving the mathematical problem, to applying this solution in the real life framework.

1. **16:711:517 Computational Methods of Operations Research**. The course will be highly interactive with individual and group assignments and with intensive computer practice. The students will be offered various problems and projects to work on during the semester. Some of the projects will involve the use of certain software packages, while some others will require coding. In addition, each of the students will be required to solve homework assignments, mostly programming tasks. Grading will be based on homeworks and projects. The course concentrates on OR modeling and problem solving with AMPL, a mathematical modeling language. Additionally, elements of other programming environments will be described, and a few assignments will be given, in particular, in PERL to realize basic data structures and combinatorial algorithms; in C++ to develop basic routines, and interface with CPLEX and/or XPressMP; and on HTML, Javascript and CSS to develop home pages and interactive web-projects.

2. **16:711:550 Nonlinear Optimization.** Convex sets. Separation. Cones. Convex functions. Elements of subdifferential calculus. Tangent cones. Metric regularity. Optimality conditions. Lagrangian duality. The method of steepest descent. Newton's method. Conjugate gradient methods. Nongradient methods. Truncated Newton's method. Feasible direction methods. Penalty methods. Dual and augmented Lagrangian methods. Sequential quadratic programming. Interior point methods. Introduction to Nondifferentiable Optimization.

3. **26:960:575 Introduction to Probability.** Foundations of probability. Discrete and continuous simple and multivariate probability distributions; random walks; generating functions; linear functions of random variable; approximate means and variances; exact methods of finding moments; limit theorems; stochastic processes including immigration-emigration, simple queuing, renewal theory, Markov chains. Prerequisite: Undergraduate or master's-level course in statistics.

4. **26:960:577 Introduction to Statistical Linear Models.** Linear models and their application to empirical data. The general linear model; ordinary-least-squares estimation; diagnostics, including departures from underlying assumptions, detection of outliners, effects of influential observations, and leverage; analysis of variance, including one-way and two-way layouts; analysis of covariance; polynomial and interaction models; weighted-least squares and robust estimation; model fitting and validation.Emphasizes matrix formulations, computational aspects and use of standard computer packages such as SPSS.

5. **26:960:580 Stochastic Processes.** The course covers the theory and modeling of stochastic processes. Topics include: martingales, stopping theorems, elements of large deviations theory, Renewal Theory, Markov Chains, Semi-Markov Chains, Markovian Decision Processes. In addition, the class will cover some applications to finance theory, insurance, queueing and inventory models.

Electives

1. **16:711:465 Integer Programming.**Overview of discrete optimization models occurring in business, engineering, industry and the sciences Modelling with integer variables Specially structured problems:knapsack, covering and partitioning problems A quick introduction to complexity theory:problems, instances, worst-case complexity, polynomial algorithms, the classes P and NP Linear programming relaxations, integrality ofsolutions, unimodularity and applications for assignment problems, shortest path and network computations Enumerative methods:branch-and-bound, implicit enumeration, bounding techniques, Lagrangean and surrogate duality Cutting planes, Gomory's algorithm, lifting and projecting for binary optimization Heuristics: greedy algorithms, local search, truncated exponential schemes.
2. **16:711:555 Stochastic Programming.**Overview of statistical decision principles.Overview of stochastic programming model constructions: reliability type models, penalty type models, mixed models, static and dynamic type models. The simple recourse model and its numerical solution techniques. Convexity theory of probabilistic constrained models.Bounding and approximation of probabilities. Numerical solution of probabilistic constrained models. Two-stage programming under uncertainty and the solution of the relevant problem by Benders' decomposition. Multi-stage stochastic programming models. Scenario aggregation. Distribution theory of stochastic programming. Applications to production, inventory control, water resources, finance, power and communication systems.
3. **16:711:557 Dynamic Programming.**The shortest path problem.The principle of optimality. Label correcting algorithms. Controlled Markov chains. Finite horizon stochastic problems. Dynamic programming equations. Discounted infinite horizon problems. Value and policy iteration methods. Linear programming approach. Applications in inventory control, scheduling, logistics. The multiarmed bandit problem. Undiscounted infinite horizon problems. Stochastic shortest paths. Methods for solving undiscounted problems. Optimal stopping; asset pricing. Average cost problems. Methods for solving average cost problems. Controlled continuous time Markov chains.Introduction to approximate dynamic programming.
4. **16:711:613 Game Theory.** Matrix games, max-min, min-max and saddle point. Pure and mixed strategies. Solvability in mixed strategies. Von Neumann's Theorem for matrix games. Bimatrix and n-matrix games. Nash equilibria and Nash solvability. Perfect equilibria and perfect solvability. Sophisticated equilibria and dominance solvability. Games in extensive, positional and normal form. Perfect information and solvability in pure strategies. Nash solvability of the cyclic games. Domination and dominance solvability. Backward induction. Dominance solvable extensive and secret veto voting schemes. Cooperative games. Coalitions. Transferable and non-transferable utilities, TU- and NTU-games. Cores and core-solvability. Bondareva-Shapley's Theorem and Scarf's Theorem. Effectivity functions and game forms, Moulin-Peleg's Theorem. Cooperative games in effectivity function form, Keiding's Theorem. Stable effectivity functions and stable families of coalitions. Intrduction to Social Choice Theory. Paradox Arrow. Social choice functions and correspondences. Boolean functions and graphs in game theory: Boolean duality and Nash solvability. Read-once Boolean functions, P4-free graphs and normal form of the positional games with perfect information. Stable effectivity functions and Berge's perfect graphs. Stable families of coalitions and normal hypergraphs. The Shapley value and the Banzhaf power index for cooperative games and approximation of pseudo-Boolean functions.
5. **26:799:661 Stochastic Models for Supply Chain Management.** This course covers quantitative methods in supply chain management under uncertainty. The emphasis is on the foundations of dynamic optimization tools in stochastic inventory models. We study key concepts such as Preservation and Attainment, Myopic Policies, optimality of (s,S) policies, capacitated inventory management, Bayesian Inventory Models, and Contracts in Supply Chains, Manufacturer's Return Policies and Retail Competition. Other topics include: Supply Contracts with Quantity

Commitment and Stochastic Demand. Option Contracts in Supply Chains. Competitive and Cooperative Inventory Policies.

6. **16:711:631 Financial Mathematics.**Cash flow streams. Financial instruments (stocks, bonds, futures, options, cash flows). Utility functions. Arbitrage pricing theory. Application of martingales. Brownian motions. Ito's lemma. Black-Scholes theory. Parabolic PDEs and their numerical solutions. The Feynman-Kac solution. Exotic and path-dependent options (chooser, barrier, lookback, Asian, Bermudan, etc.). Interest rate models (Vasicek, Hull-White). Short introduction to stochastic programming models.Markowitz mean-variance models. Bond portfolio composition models. Term structures. The use of goal programming. Dynamic option selection models. Value at Risk models.
7. **26:198:622 Machine Learning.** Conditional probability and Bayes theorem. Introduction to R. Introduction to Bayesian thinking. Single-parameter models. Multiparameter models. Introduction to Bayesian computation. Markov Chain Monte Carlo. Hierarchical modeling. Model comparison. Regression models. Gibbs sampling. Confidence and exchangeability. Conformal prediction.
8. **26:198:644 Data Mining.** Introduction to data mining tasks (classification, clustering, association rules, sequential patterns, regression, deviation detection). Data and preprocessing: data cleaning, feature selection, dimensionality reduction. Classification: decision-tree based approach, rule-based approach, instance-based classifiers. Bayesian approach: naive and Bayesian networks, classification model evaluation. Clustering: partitional and hierarchical clustering methods, graph-based methods, density-based methods, cluster validation. Association analysis: a priori algorithm and its extensions, association pattern evaluation, sequential patterns and frequent subgraph mining. Anomaly detection: statistical-based and density-based methods.
9. **26:960:576 Financial Time Series.** This course covers applied statistical methodologies pertaining to time series, with emphasis on model building and accurate prediction. Completion of this course will provide students with enough insights and modeling tools to analyze time series data in the business world. Students are expected to have basic working knowledge of probability and statistics including linear regression, estimation and testing from the applied perspective. We will use R throughout the course so prior knowledge of it is welcome, but not required.