The Academic Guide for Undergraduates Entering the Department in 2013-2014

Class of 2016
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The Undergraduate Office

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120 Sherrerd Hall

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121 Sherrerd Hall
Academic Advisors

Class of '14

<table>
<thead>
<tr>
<th>Student</th>
<th>Advisor</th>
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<tbody>
<tr>
<td>A-J</td>
<td>Prof. John Mulvey, Room 207, x8-5423, <a href="mailto:mulvey@princeton.edu">mulvey@princeton.edu</a></td>
</tr>
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<td>K-Q</td>
<td>Prof. William Massey, Room 206, x8-7384, <a href="mailto:wmassey@princeton.edu">wmassey@princeton.edu</a></td>
</tr>
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<td>Prof. Rene Carmona, Room 210, x8-2310, <a href="mailto:rcarmona@princeton.edu">rcarmona@princeton.edu</a></td>
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Class of '15

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<tr>
<td>A-G</td>
<td>Prof. Sebastien Bubeck, Room 225, x8-5130, <a href="mailto:sbubeck@princeton.edu">sbubeck@princeton.edu</a></td>
</tr>
<tr>
<td>H-N</td>
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</tr>
<tr>
<td>O-Sa</td>
<td>Prof. Birgit Rudloff, Room 203, x8-4558, <a href="mailto:brudloff@princeton.edu">brudloff@princeton.edu</a></td>
</tr>
<tr>
<td>Sb-Z</td>
<td>Prof. Erhan Çınlar, Room 328, x8-0101, <a href="mailto:ecinlar@princeton.edu">ecinlar@princeton.edu</a></td>
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Class of '16

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<tr>
<td>A-G</td>
<td>Prof. Alain Kornhauser, Room 229, x8-4657, <a href="mailto:alaink@princeton.edu">alaink@princeton.edu</a></td>
</tr>
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<td>H-N</td>
<td>Prof. Han Liu, Room 224, x8-1788, <a href="mailto:hanliu@princeton.edu">hanliu@princeton.edu</a></td>
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Department Web Page

Additional information on the department can be found at our web site: orfe.princeton.edu

All ORFE department offices are located in Sherrerd Hall.
An Introduction to the Department

The Department of Operations Research and Financial Engineering combines emerging information technologies with powerful mathematical tools to study a variety of problems that arise in the study of human processes. These problems can be roughly divided into three broad categories:

- **Physical** – The management of physical resources, including people, natural resources (such as agricultural commodities and oil), equipment (such as aircraft, locomotives, trucks and cars) and products being sold to consumers. Application domains include transportation, logistics, healthcare and manufacturing, as well as problems drawn from classical areas within engineering such as the design of structures or robots.

- **Financial** – The pricing of financial instruments, and the allocation of financial resources, with an emphasis on managing risk. Financial managers often face the problem of designing a portfolio of investments that might include stocks or the insurance of houses against earthquakes and hurricanes. The study of financial risk often takes us into the domain of the physical sciences as well as the life sciences and health care, where we may study weather patterns, earthquakes, drug treatments, epidemics or the economics of developing nations.

- **Informational** – The study, analysis and design of effective systems for storing and communicating information. This area spans the fundamentals of representing information engineering encompasses the representation of knowledge, and the study of the economics of different types of information and information technologies.

We approach these problem areas using three branches of mathematics:

- **Statistics** – This is the mathematics of working with data. It allows us to identify what is actually happening in a complex physical process from observations about this process. We might use temperature data to study the likelihood that a ski slope will have a bad winter or financial data to help determine the volatility of a financial instrument.

- **Stochastics** – Also known as probability theory, this is the mathematics of uncertainty, and we use these tools to model the possible behavior of a system in the future, where no data is available. For example, we might characterize the random behavior of interest rates, and use this to determine the price of a bond. Or we might want to estimate how many books an online bookseller should keep in stock to meet unpredictable demand.

- **Optimization** – This is the mathematics of making the best decision. Typically we study making decisions under uncertainty, balancing risks and making decisions that are likely to stand up under different outcomes. The computational problem of finding the best decision is large-scale and very complex in real applications. Such problems arise in transportation, the design of distribution networks, or the allocation of capital among competing investments.
What is Operations Research?

The field of operations research traces its foundations to World War II, although it includes dimensions that go as far back as the early days of the telephone at the beginning of the century. It embraces a set of mathematical disciplines (statistics, probability and stochastic processes, and optimization) which have been applied to a broad range of problems in business and management, finance, logistics, health care and transportation. The most common theme that runs through these problems is the efficient management of resources, where resources may be natural resources, equipment, people, and/or physical facilities.

Students in operations research may follow a management track into business or consulting, or a more technical path into fundamental research or software development. There is a burgeoning marketplace for sophisticated software packages that schedule airlines and railroads or that optimize supply chains for large manufacturing enterprises. These activities build on a growing base of “enterprise resource planning (ERP)” software packages.

What is Financial Engineering?

Financial engineering is a field that draws on the same disciplines as operations research, but with an emphasis on financial resources. Financial engineers design innovative financial instruments and strategies to meet the specific needs of individuals and corporations. To this end, financial engineers analyze and ultimately manage risks within an integrated framework, as compared with traditional piecemeal approaches. Often, new instruments are constructed based on the specific requirements of the investor. The analytical methods consist of the following: applied mathematics including stochastic calculus, probability and statistics, stochastic processes, optimization, financial economics, and computation skills. Financial engineers are in great demand. They find jobs on Wall Street, with traditional financial companies, such as banks, insurance companies, mutual funds, and financial consulting companies, as well as in the CFO’s office within mainline corporations.
Academic Program Planning

SEAS Requirements

MAT 103, 104; COS 126; CHM 201 or 207; PHY 103, 104; MAT 201, 202 or 203, 204

In addition to the engineering school requirements, there are three components to the curriculum:

1. The core requirements (six courses). These form the intellectual foundation of the field and cover statistics, probability, stochastic processes, and optimization, along with more advanced courses in mathematical modeling.

2. Departmental electives (eight or nine courses). These are courses that either extend and broaden the core, or expose the student to a significant problem area or application closely related to the core program.

3. Senior independent work. A one-semester project or a full-year thesis involving an application of the techniques in the program applied to a topic that the student chooses in consultation with a faculty advisor.

Core Program (6 Courses)

ORF 245 Fundamentals of Engineering Statistics

A study of fundamentals of statistical methods and their applications in engineering. Basic concepts of probability, discrete and continuous distributions, sampling and quality control, statistical inference, empirical models, and least squares.

ORF 307 Optimization

Model formulation, analysis, and optimization of deterministic systems. Introduction to quantitative methods: linear programming, duality theory, large-scale mathematical programs, and network analysis. Emphasis will be on applications to problem areas such as allocation of resources, transportation systems, scheduling, capital budgeting, and network problems. Two 90-minute lectures. Prerequisite: MAT 202. It is strongly recommended that COS 126 or equivalent be taken prior to or concurrently with this course.
ORF 309 Probability and Stochastic Systems

An introduction to probability and its applications. Random variables, expectation, and independence. Poisson processes, Markov chains, Markov processes, and Brownian motion. Stochastic models of queues, communication systems, random signals, and reliability. Prerequisite: MAT 201, 203, 217, or instructor's permission.

ORF 335 Introduction to Financial Mathematics (also ECO 364)

Financial engineers design and analyze products that improve the efficiency of markets and create mechanisms for reducing risk. This course introduces the basics of financial engineering: the notions of arbitrage and risk-neutral probability measure are developed in the case of discrete models; Black-Scholes theory is introduced in continuous-time models, and interest rate derivatives and the term structure of interest rates are discussed. Prerequisites: ECO 100, MAT 104, ORF 309.

ORF 405 Regression and Applied Time Series

Regression analysis: least squares and robust alternatives, nonparametric techniques (splines, projection pursuit, and neural network). Time-series: trends, seasonal effects, clinical models, state space models. Includes a final project in the form of a realistic forecasting game involving portfolio management and economic time-series data. Prerequisites: ORF 245 and Mathematics 202.

ORF 411 Operations and Information Engineering

The management of complex systems through the control of physical, financial, and informational resources. The course focuses on developing mathematical models for resource allocation, with an emphasis on capturing the role of information in decisions. The course seeks to integrate skills in statistics, stochastics, and optimization using applications drawn from problems in dynamic resource management. Students are organized into teams for a competitive game in resource management that tests modeling skills and teamwork. Prerequisites: ORF 245, ORF 307 and ORF 309, or equivalents.
### Typical Course Schedule

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<tr>
<th>FRESHMAN YEAR</th>
<th>SOPHOMORE YEAR</th>
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<tr>
<td><strong>FALL</strong></td>
<td><strong>SPRING</strong></td>
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<tr>
<td>2. MAT 104 Calculus</td>
<td>2. MAT 201 Multivariate Calc</td>
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<td>3. PHY 103 General Physics</td>
<td>3. PHY 104 General Physics 2</td>
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<td>4. Writing Requirements</td>
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<td><strong>FALL</strong></td>
<td><strong>SPRING</strong></td>
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<tr>
<td>2. Departmental Electives</td>
<td>2. Departmental Electives</td>
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# Elective Checklist

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<tr>
<th>DEPARTMENTAL ELECTIVES (8 or 9 courses - all graded)</th>
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<td>(If course is not from recommended list, provide explanation and obtain approval from Departmental Representative)</td>
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<tr>
<th>Course</th>
<th>Check</th>
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<tr>
<td>300 Level Math (or MAE 305)</td>
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<tr>
<th>HUMANITIES AND SOCIAL SCIENCE ELECTIVES (7 or more courses)</th>
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The Undergraduate Academic Program

In addition to meeting the usual Engineering School requirements, students will complete courses in the following four groups:

- Departments core requirements (6 courses) – These form the intellectual foundation of our field, and cover statistics, probability, stochastic processes, and optimization, along with more advanced courses in mathematical modeling.
- Departmental electives (8 or 9 courses depending on senior thesis choice) - These are additional courses that either extend and broaden the core, or expose the student to a significant problem area or application closely related to the core program.
- Senior Thesis - ORF 478 - A full year effort that involves a major application of the techniques in the program applied to a topic that a student chooses in consultation with a faculty advisor. Students interested in a full-year senior thesis must be willing to spend the appropriate time during both the fall and the spring semesters. Students who are unable to make adequate progress can switch to ORF 479 and be required to take nine departmental electives. Students will enroll in the spring and will receive credit for two course grades given in the spring.
- Senior Independent Project - ORF 479 (Spring semester only) - A short progress report will be due in January, (Dean’s Date) to make sure that the students have chosen a suitable topic and matched up with their advisor. The final outcome will be a report due at the end of the spring semester. The report will fully describe the research project and its results. Typically projects will take approximately 30 to 50 pages. Also, students who take the independent project will need nine departmental electives.
- Humanities and Social Science Electives (7 or more courses). B.S.E. students are required to include one course in at least four of the following six areas:
  - Epistemology and Cognition (EC)
  - Ethical Thought and Moral Values (EM)
  - Foreign Language at the 107/108 level or above (FL)
  - Historical Analysis (HA)
  - Literature and the Arts (LA)
  - Social Analysis (SA)

A student with no advanced standing will still have eight courses required to meet the engineering school requirement of 36 courses (more if the student places out of any of the SEAS requirements). Students are free to select these courses from any department, and are expected to design an academic program with his/her advisor that produces a balanced education. No course may count under more than one heading, under any circumstances.

Each student selects and schedules courses in consultation with his/her academic advisor and the Departmental Representative. While generally no exceptions in the core courses are allowed, students may design specialized programs through their choice of departmental electives. Specialized programs must be submitted for approval using the green Program Proposal Form, which must be signed by both the academic advisor and the Departmental Representative.
Department Electives (8 or 9 Courses)

The departmental electives represent courses that further develop a student’s skills in mathematical modeling either by a more in-depth investigation of core methodologies, applying these skills in specific areas of application, or learning about closely related technologies. Students must choose eight courses from the following list, with the following constraints:

- There must be at least one 300 level math course (see list below).
- There must be at least two courses from ORFE
- There can be no more than three courses from any one department (excluding ORFE)

The following courses satisfy the MAT 3xx requirement. Once the Mat 3xx requirement is satisfied the remaining courses up to a total of three may be used to satisfy part of the departmental requirement.

- MAT 320 - Introduction to Real Analysis
- MAT 322/APC 350 - Methods in Partial Differential Equations
- MAT 375 - Introduction to Graph Theory
- MAT 377 - Combinatorial Mathematics
- MAT 378 - Theory of Games
- MAT 385 - Probability Theory
- MAT 391/MAE 305 - Mathematics in Engineering I or MAT 427, (both may not be taken because content is too similar)
- MAT 392/MAE 306 - Mathematics in Engineering II
- MAT 427 - Ordinary Differential Equations
- MAT 486 - Random Process
- MAT 522 - Introduction to Partial Differential Equations

All Other departmental electives:

- ORF 311 - Optimization Under Uncertainty
- ORF 350 – Analysis of Big Data
- ORF 375 - Junior Independent Work
- ORF 376 - Junior Independent Work
- ORF 401 - Electronic Commerce
- ORF 406 - Statistical Design of Experiments
- ORF 407 – Fundamentals of Queueing
- ORF 409 - Introduction to Monte Carlo Simulation
- ORF 417 - Dynamic Programming
- ORF 418 - Optimal Learning
- ORF 435 - Financial Risk Management
- ORF 467 - Transportation
- CEE 303 - Introduction to Environmental Engineering
- CEE 460 - Risk Assessment and Management
- CHM 303 – Organic Chemistry I
- CHM 304 – Organic Chemistry II
• COS 217 - Introduction to Programming Systems
• COS 226 - Algorithms and Data Structures
• COS 323 - Computing for the Physical and Social Sciences
• COS 340 - Reasoning about Computation
• COS 402 - Artificial Intelligence
• COS 423 - Theory of Algorithms
• COS 425 - Database and Information Management Systems
• ECO 310 - Microeconomic Theory: A Mathematical Approach
• ECO 317 - The Economics of Uncertainty
• ECO 332 – Economics of Health and Health Care
• ECO 341 - Public Finance
• ECO 342 - Money and Banking
• ECO 361 - Financial Accounting
• ECO 362 - Financial Investments
• ECO 363 - Corporate Finance and Financial Institutions
• ECO 414 - Introduction to Economic Dynamics
• ECO 418 - Strategy and Information
• ECO 462 - Portfolio Theory and Asset Management
• ECO 464 - Corporate Restructuring
• ECO 466 - Fixed Income: Models and Applications
• ECO 467 - Institutional Finance
• EEB 323 – Theoretical Ecology
• ELE 485 - Signal Analysis and Communication Systems
• ELE 486 - Digital Communication and Networks
• MAE 433 - Automatic Control Systems
• MOL 345 – Biochemistry
• MOL 457 – Computational Aspects of Molecular Biology
• NEU 437 – Computational Neuroscience
• NEU 330 – Introduction to Connectionist Models

Students often wish to follow a theme in their selection of courses. Below are a few possible themes:
• Financial Engineering: ORF 435, 311; ECO 362, 363, 462
• Engineering systems: ORF 467; COS 226, 323; ELE 485; MAE 433.
• Information systems: ORF 401, 467; COS 226; ELE 485, 486
• Applied mathematics: MAT 375, 378, 320, 486; COS 341, 423; MAE 306
• Pre-Med/Health Care: CHM 303, 304; MOL 345, 457; ECO 332; ORF 401, 418
Taking Courses at Other Schools

Students may take courses at other schools during the summer, during a semester off, or during a year abroad. The rules are slightly different depending on the activity. If you are considering taking a replacement course during the summer or a semester off, you need to obtain a form from West College where you describe the course that is being taken, and what course at Princeton is being replaced. This is particularly important if you want the course to count toward some requirement. Read the form carefully. It requires that you obtain the approval of the home department for the course. For example, if you wish to take a replacement course for MAE 305, you have to get the signature of the Departmental Representative from MAE. A replacement for an ORFE course requires the signature of the Departmental Representative of ORFE. It is a good idea to have a syllabus or at least a detailed description of the course before obtaining approval.

If you wish to take a semester or a year abroad, you need to obtain the signature of the Departmental Representative of ORFE, in addition to the approval of the course of study committee.
Departmental GPA, Graduation Requirement, Honors and Prizes

Departmental GPA: Prior to graduation, the department will calculate each student's Departmental Grade Point Average (GPA). The Departmental GPA is computed as the average of 10 grades. For students choosing the 2-semester Senior Thesis option (Orf 478) the 10 grades are: twice for Orf 478 plus the best 8 Princeton Graded (some courses may have been taken at other universities and are not eligible) 300-level and above courses from the set of {ORFE Core Courses (Orf 307,309,335, 405, 411, Math 300-level) and approved Departmental Electives (either from the published list or individually approved by the departmental representative)}. For students choosing the 1-semester Senior Independent Research option it is the Orf 479 grade plus the best 9 Princeton Graded 300-level and above courses from the set of {ORFE Core Courses and approved departmental electives}. Note, while two 200-level courses may be included among the Departmental Electives, no 200-level courses are counted in the departmental GPA.

A minimum 2.0 Departmental GPA is required for graduation, and as the major, not the sole, determinant of honors. The overall academic quality of the entire ORFE class and academic performance in individual classes is also taken into account in the faculty's decision in awarding honors.

Graduation Requirement: Core Courses and Departmental Electives **may not be taken on a PDF (Pass, D, Fail) basis.** Equivalent versions may be taken at other Universities but only prior formal written permission. A passing grade must be received in each ORFE Core Course and each Departmental Elective. To graduate, a student must satisfy the University's 36 course requirement, the SEAS requirements for Physics, Chemistry, Math and Computer Science, ORFE's Core and Departmental Elective requirement and achieve a Departmental GPA of 2.0 or greater.

Honors: Highest Honors, High Honors and Honors are awarded by the ORFE faculty to those graduating seniors who have demonstrated the highest levels of academic achievement. Departmental GPA is the major criterion; however, each student's overall academic record and overall quality of the entire class are also considered in the awarding of these honors.

Prizes: The ORFE faculty also awards a few individual prizes for specific superior achievement in a few defined categories.

Junior Independent Work

Students wishing to do Junior Independent Work should contact the Departmental Representative who will help the student identify a faculty mentor and a topic. The requirements for satisfactory completion of the study (such as reports, examinations, etc.) are set by the faculty mentor, not the Department, and the student should be clear about them when the work is begun. If a one-term project is being undertaken, the student registers for ORF 375 for the fall term and ORF 376 for the spring term.
Senior Thesis (ORF 478)

The senior thesis is a year long undertaking except there will be greater emphasis on the work accomplished during the first semester. Students interested in a full-year senior thesis must be willing to spend the appropriate time during both the fall and the spring semesters. Students who are unable to make adequate progress can switch to the Senior Independent Project (below) and be required to take nine departmental electives. Two course grades will be given in the spring.

A report on the background and research to date will be due at the end of the fall semester (roughly 30+ pages). This report should form a significant portion of the full senior thesis. The research results will be presented to faculty and students at the end of the spring semester.

In addition, there will be a selection process to insure that students will be able to conduct a two-semester research project. As with the independent project, there will be match of faculty and students based on the preferences of the students. A 3-5 page prospectus is expected for students who wish to pursue the senior thesis (due in September).

Senior Independent Project (ORF 479, Spring Semester Only)

Students will choose an advisor during the upcoming spring semester, based on the usual arrangement – attending presentations by the ORFE faculty, reading the shopping guide (which describes faculty interests and expertise), and meeting with individual faculty members. Students will select a broad topic, and rank faculty according to their preferences.

A short progress report will be due in January, (Dean’s Date) to make sure that the students have chosen a suitable topic and matched up with their advisor. The final outcome will be a report due at the end of the spring semester. The report will fully describe the research project and its results. Typically projects will take approximately 30 to 50 pages. Also, students who take the independent project will need nine departmental electives rather than eight.

Certificates of Interest to ORFE Students

The following certificate programs complement well with ORFE and are thus popular with students:

- Applications of Computing
- Engineering Management Systems
- Environmental Studies
- Finance
- Program in Applied and Computational Mathematics
- Program in Robotics and Intelligent Systems
- The Woodrow Wilson School
Faculty and Their Research Interests

Sebastien Bubeck, Assistant Professor
Multi-armed bandits, online optimization, stochastic optimization, statistical learning theory, high dimensional statistics.

Rene A. Carmona, Professor
Research interests center on stochastic analysis and its applications to problems in financial mathematics: pricing in incomplete markets, credit and energy derivatives and modeling of the emissions markets. Other topics of interest include stochastic partial differential equations, stochastic control and stochastic games, filtering, and the statistical analysis of financial data.

Patrick Cheridito, Professor
Stochastic modeling, optimal control, finance, insurance, risk management.

Erhan Çinlar, Professor

Jianqing Fan, Professor
Research interest focus on statistical analysis and its applications in finance, biological science and health sciences. They include Financial Econometrics, Computational biology, high-dimensional statistical learning, nonparametric modeling, non-linear time series, and other statistical theory and methods.

Alain L. Kornhauser, Professor
Development and application of operations research and other analytical techniques in various aspects of Autonomous Vehicles, aka "SmartDrivingCars", including

- the fundamental design of computer vision techniques for the rapid classification and identification of the driving environment,
- analysis and classification of collision-free driving scenarios,
- quantification of accident risk and the investigation, formulation and design of "pay-as-you-drive, pay-as-the-car-drives" insurance,
- Investigation and creative design of the human-computer interfaces for SmartDrivingCars
- operational and feasibility analyses of autonomousTaxi (aTaxi) systems
Han Liu, Assistant Professor

Research interests focus on statistical machine learning and probabilistic graphical models, with applications in analyzing massive, and complex datasets. Specific interests include large-scale semiparametric inference, statistical optimization, high dimensional graph estimation, and large-scale adaptive inference.

William A. Massey, Professor

Management in communications and healthcare, queueing theory, dynamic rate queues, stochastic networks, dynamic optimization.

John M. Mulvey, Professor

Expert on optimization under uncertainty, with emphasis on financial planning applications. Develops strategic planning systems for financial organizations, such as American Express, Towers Perrin - Tillinghast, Merrill Lynch and Siemens. Interested in the optimization of large organizations by means of decentralized optimization methods. Current research involves optimizing multi-strategy hedge funds.

Warren B. Powell, Professor

Stochastic optimization and optimal learning, primarily in the contextual domain of energy systems analysis. I am interested in a wide range of problems in energy and environmental systems where we need to learn how to design and control these systems to improve the efficiency of how we use our natural resources in the presence of different forms of uncertainty. Applications include topics such as dynamic pricing of electricity, the impact of electric vehicles on the power grid, managing the use of energy from wind and the sun in the presence of different forms of storage, understanding and exploiting flexibility in demand, endogenous learning in climate change, developing efficient trading strategies for electricity in the presence of heavy-tailed spot prices, and understanding auctions and markets for energy assets. For more information, please see http://energysystems.princeton.edu.

Philippe Rigollet, Assistant Professor

High-dimensional statistics, statistical learning theory, computational complexity, aggregation theory, online learning.

Birgit Rudloff, Assistant Professor


Ronnie Sircar, Professor

Financial mathematics; stochastic models, especially for market volatility; optimal investment and hedging strategies; analysis of financial data; credit risk; employee stock options; dynamic game theory; energy and commodities markets.
Robert J. Vanderbei, Professor

Algorithms for, and applications of, linear and nonlinear optimization. Applications of special interest include high-contrast imaging, orbital dynamics/mechanics, parametric linear programming as it arises in, say, machine learning, and parameter estimation under sparse sampling as it arises for example in generating level-of-difficulty measures.

Ramon van Handel, Assistant Professor

Research interests focus on probability theory and stochastic processes, motivated by applications in engineering and science. Specific interests include Markov and hidden Markov processes, ergodic theory, stochastic calculus and stochastic analysis, nonlinear filtering and prediction, information theory, stochastic control, and empirical processes.
Research and Teaching Studios

Students in the department often participate in the research interests of the faculty, and may take advantage of the facilities used for this work. This includes:

- CASTLE Lab works on problems in dynamic resource management, with ongoing projects in chemical distribution, railroads, trucking and the airlift mobility command. Students regularly participate in the analysis of research questions arising in these projects, and have access to both data and specialized tools developed in the studio to help with their work. To learn more about CASTLE Lab, see its web page: http://www.castlelab.princeton.edu.

- The Financial Engineering Studio provides students with access to financial data support research into methods for managing risk. Research topics include the development of advanced financial instruments which can be used by insurance companies, major manufacturing companies and investment houses to control risk exposure.

- The Financial Econometrics Studio works on a variety of quantitative problems from finance using statistical techniques and financial economic theory. These include valuation of financial derivatives, optimal portfolio allocation, risk modeling and management, volatility estimation, modeling and analysis of financial data, and simulation of financial system. The studio also studies financial econometrics theory and provides various fundamental insights into the statistical inference problems from financial markets.

- The Statistics Studio is interested in statistical methods in financial econometrics and risk managements, computational biology, biostatistics, high-dimensional statistical learning, data-analytic modeling, longitudinal and functional data analysis, nonlinear time series and justifying statistical methods that are used to solve problems from the frontiers of scientific research. This is expanded into other disciplines where the statistics discipline is useful.

- Princeton Autonomous Vehicle Engineering (PAVE) is a student-led research group. The group consists primarily of undergraduates but is assisted by a diverse group of graduate students and talented faculty advisors. The primary research is focused on producing an autonomous vehicle that will complete the DARPA Urban Challenge within the six hour time limit.
Career Paths

Updates from Recent ORFE Graduates

Meghan Fehlig, '02
I'm working as a transportation engineer in the transportation planning department at Parsons Brinckerhoff (Princeton, NJ office). I became interested in this field after taking Prof. Kornhauser's transportation course and doing senior thesis research on the traffic woes of the Route 1 Corridor. Rarely a day goes by that I don't rely on something I learned during my thesis research or ORFE courses, be it traffic condition analysis, general research skills, MS Excel work, or NJ transportation history. A real bonus about being in this field with an ORFE degree is having a solid background in economics. Many of the exciting transportation innovations are market-based solutions and my ORFE studies have uniquely positioned me to work on these innovations with a different approach from my civil engineer and urban planner colleagues.

Daniel Nash, '03
I am a Director of new Growth Platforms at Avery Dennison, a $6.5 billion dollar manufacturing and consumer products company with expertise in pressure-sensitive technology, and retail branding and information solutions. As such, I am responsible for identifying and building new growth opportunities for the company. For the past year, I have focused on the healthcare industry, working to leverage Avery Dennison’s RFID technology to improve key processes in hospitals. Prior to Avery Dennison, I worked as a consultant for the Boston Consulting Group serving in both the Singapore and Boston office, and in the Corporate Finance department of The Walt Disney Company. I received my MBA from Harvard Business School in 2008.

My ORFE education continues to provide a significant advantage relative to my peers. The ORFE department taught me how to quickly identify the key drivers of a new market or successful product launch, so that I can efficiently validate my assumptions and limit my downside risk. I believe there is no better education for a successful career in business.

Katherine Milkman, '04
After completing my ORFE degree, I received a Ph.D. from Harvard University's joint doctoral program in Computer Science and Business. I am now an assistant professor at the Wharton School at the University of Pennsylvania where I teach undergraduates and MBAs about decision making and behavioral economics. When I’m not in the classroom, I spend my time on research that documents various ways in which individuals systematically deviate from making optimal choices. I am particularly interested in understanding what factors lead people to undersave for retirement, exercise too little, eat too much junk food, and watch too many lowbrow films. Recently, I have also begun to study race and gender discrimination, focusing on how a decision's context can alter the manifestation of bias. I have published articles in leading academic journals such as Management Science and the Proceedings of the National Academy of Sciences, and my work has been featured by numerous media outlets including The New York Times, BusinessWeek, The Economist, and NPR. In 2011, I was recognized as one of the top 40 business school professors under 40 by Poets and Quants.
Kimberly Mattson, ’05

I am an Investment Associate at Bridgewater Associates, an institutional hedge fund manager in Westport, CT. We deal with large institutions - pension funds, college endowments, central banks. Most of my work revolves around solving problems that deal with portfolio structuring. I use a lot of the concepts I learned in ORFE in my day-to-day work. I use a lot of the portfolio math I learned in ORF 435 to figure out a portfolio's risk and return characteristics. We also have a tool that calculates a client’s optimal portfolio using a Monte Carlo simulation process. I’ve even used some of the ideas I developed in my senior thesis, which used implied volatility in currency options to estimate the chance of a currency crisis, in my job, since Bridgewater manages currencies and options as part of its investment strategy. In my opinion an ORFE degree is the most flexible major to have at Princeton because it teaches a wide array of skills to apply basically anywhere after college.

Jacqueline Ng, ’06

Since graduating as an ORFE in 2006, I have worked in a variety of roles that have drawn upon the knowledge and skills I gained as an ORF major. After graduation, I spent nearly 6 years at Morgan Stanley, where I worked in US Government Bond Trading, Sales & Trading Strategy and US Equity Research. During my time at Morgan, I also pursued an executive-MBA at Columbia University. I recently left Morgan Stanley to work for Microsoft in a strategy and finance type position for their consumer advertising support business.

My undergraduate degree in ORFE has aided me tremendously in each one of my job functions. At a high level, my ORF classes taught me how to think quantitatively and analytically – which has been a versatile skill that has helped me grasp new concepts quickly in the workplace. The vigorous ORFE curriculum prepared me well for the challenges of the workplace, and has given me confidence when faced with complex problems.

On a more specific level, I find myself constantly drawing upon the knowledge I gained in my ORFE classes. For example, Professor Sircar’s ORFE 335 class (Introduction to Financial Engineering) taught me about various fixed income products and pricing models. As a bond trader, I frequently used similar pricing models on a day-to-day basis, in addition to various probability models, statistics and historical regressions. Additionally, my undergraduate classes prepared me well for business school, where my solid foundation in operations facilitated my understanding of our operations management MBA coursework. Finally, in my current role at Microsoft, I find that the knowledge I’ve gained as an ORF major accompanies me both directly and indirectly in every challenge and problem I face in the workplace.

Zachary Kurz, ’08

I am working as an investment banking analyst in Morgan Stanley’s Mergers & Acquisitions Group. I am responsible for building financial models in Excel and creating presentations for our senior bankers to present to the Firm’s clients. I have been part of some really interesting transactions, including the recent $46 billion merger of Merck and Schering-Plough, two large pharmaceutical companies. I frequently use a lot of the math skills I learned as an ORFE major and the rigorous foundation has definitely given me a leg up on other young people at the Firm. In particular, a lot of the programming skills I acquired at Princeton have been incredibly useful. I am still unsure about where my career is headed but I am eager to further immerse myself in the financial world.
Jonathan Lange, '09

I am an associate in the private equity group at Bain Capital. We invest in market-leading companies in a wide range of industries and try to optimize operations during our ownership. In my first year, I have evaluated several interesting potential transactions, primarily in media and technology. Prior to Bain Capital, I spent two years as an analyst in the Technology, Media, and Telecommunications investment banking group at Goldman Sachs, where we advised companies on mergers, acquisitions, IPOs, and other financing transactions. Through my roles at Goldman Sachs and Bain Capital, I have had the chance to travel to across North and South America and work directly with management teams, both as an advisor and investor. My ORFE education definitely gave me a great foundation in financial modeling and has been a huge advantage as I work through the theoretical aspects of valuation and the financial impacts of potential transactions.

Teck Hsien Ho '10

I am an analyst at the New York office of Cornerstone Research, an economic and litigation consulting firm. We provide attorneys with analytical support in all phases of commercial litigation and regulatory proceedings, from identifying relevant issues and developing case strategy to engaging expert witnesses, conducting research, and preparing effective testimony. In my first year, I have been working on a complex case involving highly specialized credit and interest rates derivatives. The analysis I’ve done so far include market liquidity analysis, valuation of these derivatives, and netting analysis under a variety of frameworks and assumptions. Graduating from the ORFE department gave me a great foundation in financial modeling and a high comfort level with the quantitative aspect of the work we do, giving me a great advantage as I work through progressively advanced assignments. A lot of the programming skills picked up during my time in the ORFE department have also helped greatly.

Kate Hsih '10

At Princeton, I studied an interdisciplinary curriculum that treaded not only in ORFE courses, but also in the natural sciences, global health, and even the humanities. My goal was the develop a holistic understanding of quantitative and qualitative approaches to interpreting and solving real world problems. After graduating in 2010, I worked as a Princeton ReachOut56-81 International Fellow with Wellbody Alliance (formerly Global Action Foundation), a global health NGO focusing on sustainable community-based health interventions in the rural diamond-mining district of Sierra Leone. There, I was involved in a wide range of projects including HIV home-based care, reproductive health peer education, social entrepreneurship in agriculture, amputee health, primary care in resource-limited environments, and more. I also learned about what it takes to operate a startup in this field and about the challenges and complexities of navigating in a developing environment with different cultural and professional norms. In addition to working in the NGO space, I became interested in ethnography in Sierra Leone, particularly on the topic of female genital cutting. This year, I am studying a Master of Science degree in Medical Anthropology at the University of Oxford prior to returning to the US for medical school.

While I have not directly applied many of the mathematical skills I learned in my ORFE core courses, my engineering training is omnipresent in managing my day-to-day operations. It shapes the way that I think, analyze, and organize my thoughts when presented with new problems or projects. Moreover, I have found that my ORFE degree and unusual academic and extracurricular background has been an asset in finding internship or employment opportunities because it allows me to bring unique insights to the table. ORFE teaches students to model real-world situations and make optimal and efficient decisions under uncertainty or with limited information - these tools are necessary in virtually any field, particularly in healthcare or global health. I encourage students to consider using their ORFE education to pursue unconventional careers, as it may open doors to greater responsibility and intellectual creativity. I am happy to connect any students interested in the healthcare, international development, or medical anthropology.
Vince Jeong ’11

I am a Business Analyst at McKinsey & Company, a global management consulting firm. We advise businesses, governments, and institutions on how to solve strategic problems they face. Projects I have worked on include development of a new B2B marketing strategy for an insurance company, transformation of an industrial company’s maintenance function, and organizational re-design of a division at a global bank.

The specific nature of my work varies significantly from project to project, but designing and performing critical analyses is at the core of my responsibilities. For example, on one of my studies, I was in charge of building an Excel-based business case around the economics of outsourcing for our client. The implications of this model were presented to the CEO and the CFO as a key component of our team’s final recommendation.

I am very glad that I majored in ORFE because it prepared me well for the work I have to do now. While my day to day work does not require specific content knowledge I have learned from ORFE, going through its rigorous curriculum has taught me how best to conceptualize complex problems, structure key analyses that get to the heart of the matter, and carry out the analyses efficiently. Problem solving is central to my job, and I feel well equipped to tackle any problem at hand.

Chetan Narain ’11

I’m working at Google on the Search Ads Quality team, which is responsible for deciding which ads to show on the search result page and thus brings in the majority of Google’s revenue. The job is a blend of engineering, computer science, and mathematics, which is exactly what ORFE is all about. I’ve worked on projects where we try to predict how many people will click on an ad, something that requires substantial data crunching, strong mathematical analysis, and a good understanding of how people’s minds works. My position is right at the confluence of mathematics, finance, and computer science, and was a natural extension of the similarly multifaceted education I got in the ORFE program.

Anna Zhao ’12

I work at the NBA League Office in the basketball operations department. My department functions like the government of basketball, as we oversee the on-court activities, manage rule changes, and address any questions or concerns from teams. My most direct ORFE project has been when I used my foundation in probability (ORF 309!) to evaluate teams’ drafting abilities (not gonna lie, I was pretty excited about this). Most of my time has been spent on performing statistical analysis on a variety of areas, such as injuries, the NBA Draft, and the NBA Development League. Even when my job has no math involved, like stuffing All-Star Game gift bags, what I learned about operations research helps increase efficiency. I’m glad that I switched to ORFE because I learned how to approach solving complex problems in real-world situations, how to code to manipulate raw data into a useful form, and how to complete tasks efficiently.
Class of 2012 Senior Thesis Titles

Computational Music: Feature Distance Models and Stochastic Genre Classification Schemes

Numerical Methods for Pricing Discretely Monitored Consecutive Parisian Options

Food Prices and Fundamentals: Diminishing Role of Fundamentals in Determining Agricultural Commodity Prices

Counterparty Credit Risk: An Exploration of Hidden Dangers in Exchange-Traded Products

Bid and Ask Prices in Options Markets with Transaction Costs

Natural Gas Power Generation in the Presence of Wind: A Mixed Integer Linear Programming Approach to the Hour-Ahead Unit Commitment Problem

Analyzing the Regional Greenhouse Gas Initiative: A Model of Carbon Dioxide Emissions in New Jersey

Predicting Success in High School Virtual Courses

Leading Industries: Evidence from Emerging Markets and Application of Regime-Switching Investment Models

A Clustering Based Algorithm for Efficient Online Nonparametric Regression

Examining the Impact of Electric Vehicles on Today’s Power Grid

Parametrization of Public Policies to Incentivize Investment in Geothermal Power Projects in the Philippines

Shared Autonomous Taxis: Implementing an Efficient Alternative to Automobile Dependency

Applications of Recombining Stochastic Volatility Trees

Too Big to Fail: A Market Study of the Banking Consolidation Phenomenon on Wall Street

Dynamic Rate Queues for Efficient Staffing of Hospital Cleaning Services

Future Prospects of OPEC and the Oil Market

Dynamic Pricing of Electric Vehicles Charging Locations: An Application of Optimal Learning

Online Portfolio Selection in U.S. and Emerging Markets Equities

Redesigning Highway Interchanges to Save the World: HITOSs as a New Paradigm for Sustainable Development

A Stochastic Unit Commitment Model in the Presence of Offshore Wind Energy

Utility Indifference Pricing in Markets with Transaction Costs: Vector Optimization Approach
First-Passage Percolation and Stochastic Growth on Intelligent Vertices
Fitting Regression Models to Global Temperature Trends
Sensitivity Analysis on a Transitive-State Markov Model of Diabetes
Adding the Missing Player: The effect of Including Consumers in the Oil Futures Market
A Statistical Approach to Running an NBA Team
Electricity Forward and Option Hedging System
Optimal Temporal-Spatial Deployment of Urban Law Enforcement Personnel: Theory, Analysis and Implementation
Imitating Masters: On Replicating the Investment Returns of Fine Art
Electricity Markets in Our World: A View into the Construction of Stochastic Power Pricing Models
Optimal Length-of-Stay Policies for Heart Failure Patients in a New Health Care Environment
Analyzing, Modeling, & Trading the NASDAQ Crosses
Sustainable Energy Economics: Optimizing the integration of Renewables in Guatemala
Maximizing Heart Organ Flow in the Oran Transplant Network through Region Design
Over or Under: Using Machine Learning Techniques to Beat NCAA Football Totals
Environmental Justice Under the Allowance Trading Program: A Robust Approach to Modeling the Equity Effects of SO2 Emissions Trading
A Comparison of Methods of Pricing Spread Options in Markets with Transaction Costs
Explaining Credit Default Swap Premia: Analyzing the Relationship Between Global CDS Spreads and Stochastically Modeled Default Probabilities
Modeling Systemic Risk Using Networks
Staffing Technical Support Centers: Forecasting for Multi-Class, Processor Sharing Queues with Dynamic Arrival Rates
An In-Depth Analysis of the Employment Situation During the 2008 Recession
Simulation Techniques for Bayesian Image Recovery in Lenz-Family Models
Predatory Trading on Index Rebalance Dates: Flow Abnormalities and a Case for Front-Running
Replication and Comparison of Commodity Futures Trading Strategies
TDLoo: Getting a Grip on To-Do Lists
Grid Impacts of Charging Electric Vehicles in Urban Areas: A Case Study of Queens, NY
Harry Potter’s Life in the Fast Lane: Using ORFE Magic to Forecast Speeds on State Route 167 (Hermonie Granger’s Thesis for a Muggle Studies Degree)
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