

Ph.D. Program in Quantitative Methods

The Krannert School's doctoral program in Quantitative Methods (QM) involves research and teaching in optimization, probabilistic and stochastic models, statistics, and related applications.

Optimization and its applications explore resource allocation modeling and solutions that frequently arise in managerial decision making. In an era of dwindling resources and increasing competition, optimization questions have assumed a new and urgent importance. Doctoral seminars focus on advanced optimization methodologies and applications. Related courses are available in the schools such as industrial engineering, electrical engineering and computer sciences. Faculty collaboration with other areas of management and related engineering programs enables students to participate in research on a stimulating range of optimization theory and applications. Current areas of faculty interest in optimization include linear programming, nonlinear programming, integer programming, combinatorial optimization, distribution, location, production planning, scheduling, transportation, networks and telecommunication.

Probabilistic and stochastic modeling and applications concentrate on quantifying the effects of uncertainty in managerial decision making. Stochastic models play an important role in understanding and analyzing many complex business processes. Students are encouraged to take courses from several other departments such as industrial engineering, statistics, mathematics, electrical engineering and computer sciences to strengthen the foundation of their research capabilities. Current faculty research interests in probability and stochastic modeling include inventory management, distribution, supply chain management, stochastic optimization, procurement and production planning.

Statistics and its applications address managerial problems in which randomness or uncertainty complicates the decision environment. This specialization emphasizes in-depth study of the relevant methodology with the flexibility to apply these methods to any areas of management. Courses from departments such as economics, statistics, and industrial engineering as well as other areas of management offer the student a rich variety of topics for applied statistics research. Current faculty research interests in applied statistics include data mining, reliability theory, stochastic marketing models, auditing and acceptance sampling, statistical decision theory, and statistical quality and process control.

Basic proficiency in decision analysis, mathematical programming, mathematical statistics, probability theory and stochastic models is required for all doctoral candidates in the Quantitative Methods area. Advanced seminars explore selected research topics concerning quantitative methods and applications to management problems. The plan of study may include mathematics, optimization, statistics, computer science, management information systems, operations management, industrial engineering, and economics courses.

The biography of quantitative methods faculty can be found in the Krannert faculty online directory at http://www.mgmt.purdue.edu/faculty_research/home.asp.

Unique Features

- Faculty on editorial boards for top academic journals. For example, Prof. Kwei Tang was the Department Editor of *IIE Transactions*.
- Publications in top-tier journals by faculty and Ph.D. students. The top-tier journals in the Quantitative Methods area include *IIE Transactions*, *INFORMS Journal on Computing*, *Journal of the American Statistical Association*, *Journal of Global Optimization*, *Journal of Quality Technology*, *Management Science*, *Manufacturing and Service Operations Management*, *Mathematical Programming*, *Mathematics of Operations Research*, *Naval Research Logistics*, *Operations Research*, *SIAM Journal on Optimization*, and *Technometrics*.
- Doctoral fellowships available.
- Small program with low student-faculty ratio.
- Active interactions with other functional areas of the school and universities.
- By the undergraduate program rankings of *U.S. News & World Report*, Krannert's Quantitative Analysis/Methods area has remained firmly in the top five. In the year of 2007-08, Krannert's Quantitative Analysis/Methods area was ranked No. 4 behind MIT, University of Pennsylvania and Carnegie Mellon, and was also No. 1 among all public universities.
- By the master's program rankings of *U.S. News & World Report*, Krannert's MBA program was ranked No. 8 nationally in Quantitative Analysis in the year of 2002. By the master's program rankings of *Wall Street Journal*, Krannert's MBA program was ranked No. 1 in the regional category in the years of 2004 and 2005.

Student Profile (what we look for in an applicant)

- Strong analytical, computer science and mathematical background.
- Fluency in speaking and writing in English.
- Work and business experience not required.

Detailed Program Requirements

Study carefully the following website for the general requirements for the Ph.D. students: http://www.krannert.purdue.edu/programs/phd/degree_programs/Intro_to_Management.asp. To satisfy the Quantitative Methods area requirement, a student must complete a minimum of 12 credit hours of doctoral-level courses. Students should work closely with the area academic advisor in selecting the courses. The purpose of the minor area requirement is to build on the Quantitative Methods area coursework and to broaden the student's knowledge base. To satisfy the minor area requirement, a student must complete a minimum of 6 credit hours of doctoral-level courses in related fields. Students should consult with the area academic advisor who represents their chosen minor area as they select the courses for their minor. The courses that meet the minor area requirement must be approved by the area academic advisor.

Plan of Study and Evaluation

Ph.D. students are required to keep constant contact with faculty members in the Quantitative Methods area. Under the advice of faculty members, students will take the basic quantitative methods courses in the first two school years. A list of recommended courses is provided near the end of this document. The Ph.D. seminar courses offered by the Operations Management area and the Management Information Systems area in the Krannert School are recommended as possible avenues for completing a minor.

Students are also strongly encouraged to attend various research seminars. Refer to the internal website for seminar information in the Krannert Seminar Calendar.

Research papers are required for the first and second summers of graduate study, and they are designed to give students an early introduction to research work. The papers may be done individually or jointly with faculty members. In many cases, work on the summer papers leads to the work on the Ph.D. dissertation.

Students are required to submit a formal plan of study to the Graduate School by the end of the Spring Semester of their second school year in the doctoral program, and prior to taking the preliminary examination. Selected research papers will be assigned to students in preparation for the preliminary examination. The preliminary exam will be based on the assigned papers as well as the second summer research paper.

Every Ph.D. student is required to maintain the minimum GPA requirement of the graduate school. All scores of the courses and the preliminary examination as well as the quality of the first summer research paper will be evaluated at the end of the second year. This evaluation will be used to decide whether the student is qualified for continuing to work towards the Ph.D. dissertation proposal, dissertation, and Ph.D. degree.

Doctoral Dissertation Proposal/Dissertation Committee Requirement

Within twelve months after passing the preliminary examination, each student must formally present and defend a dissertation research proposal to his/her dissertation committee. To be accepted, the proposal must represent substantial progress towards completion of a doctoral thesis along with a statement of further work to be performed. Once accepted by the committee, the proposal is considered a "contract" that will guide the student towards completion of the dissertation. A student may be dropped from the program if there is a significant delay in achieving an acceptable proposal.

Defense of Dissertation

Each student is required to make a public defense of his/her dissertation. The required procedures for holding a dissertation defense are listed in the revised Ph.D. Program in Management.

Development of Teaching Experience

As part of the training in the Ph.D. program, all Ph.D. students are required to involve in teaching of undergraduate students. The Ph.D. students in the Quantitative Methods area are first appointed as Teaching Assistants (TAs) to help instructors in teaching undergraduate courses. Then each Ph.D. student will be assigned to teach an undergraduate core course (Business Statistics or Management Science) according to the teaching schedule of the area. The excellent Ph.D. teachers will be awarded and recognized by the Krannert's Ph.D. program as the distinguished or outstanding teachers of the year.

Recommended Courses

- **Ph.D. Courses Taught by QM Faculty** (check topics and availability)
- **Applied Statistics:**

ECON 67000 Probability Theory and Mathematical Statistics

STAT 51100 Statistical Methods

STAT 51700 Statistical Inferences

STAT 52800 Introduction to Mathematical Statistics (Requires STAT 51900)

ECON 67100 Econometrics

MGMT 67200 Quantitative Methods III

STAT 51200 Applied Regression Analysis

STAT 52500 Intermediate Statistical Methodology

ECON 67200 Topics in Econometrics (Requires ECON 67100)

MGMT 67700 Research Methods: Applied Multivariate Analysis

STAT 52400 Applied Multivariate Analysis

- **Advanced Statistics/Econometrics:**

ECON 67200 Topics in Econometrics (Requires ECON 67100)

ECON 67300 Time Series Methods (Requires ECON 67200)

ECON 67400 Cross-sectional Econometrics (Requires ECON 67200)

MGMT 67700 Research Methods: Applied Multivariate Analysis

MGMT 67900 Nonparametric Methods for Research

STAT 51400 Design of Experiments Fundamentals

STAT 52000 Time Series and Applications

STAT 52400 Applied Multivariate Analysis

STAT 52600 Advanced Statistical Methodology

STAT 52900 Bayesian Statistics and Applied Decision Theory

STAT 65700 Mathematical Statistics I Sequential analysis

- **Economics:**

ECON 51500 Macroeconomics

ECON 60700 Price Theory

ECON 61000 Game Theory

ECON 6*00** ECON PhD Course Elective: Information and Uncertainty (ECON 67600), Industrial Organization (ECON 62000 or ECON 62100), Experimental (ECON 69000), Macroeconomic Theory (ECON 60800)

- **Mathematics:**

MATH 50400 Real Analysis

MATH 51100 Linear Algebra with Applications

MATH 53200 Elements of Stochastic Processes (same course as STAT 53200)

MATH 54400 Real Analysis and Measure Theory

- **Optimization:**

IE 53500 Linear Programming (Prerequisite for all the 60000-level IE courses listed)

IE 63300 Dynamic Programming

IE 63400 Integer Programming

IE 63500 Theoretical Foundations of Optimization

IE 63900 Combinatorial Optimization

- **Stochastic Processes:**

IE 53900 Stochastic Service Systems

IE 63600 Stochastic Models in Operations Research II

MATH 63800 Stochastic Processes I (same course as STAT 63800)

MATH 63900 Stochastic Processes II (same course as STAT 63900; continuation of MA 63800)

- **Special Topic:**

CS 58000 Algorithm Design, Analysis, and Implementation (Requires **CS 25100** Data Structures)

IE 53700 Discrete Optimization Models and Applications

IE 63100 Heuristic Programming

TIMETABLE FOR PHD STUDENTS IN QM AREA:

Term	First Year	Second Year	Third Year	Fourth Year
Fall	<p>(1) Coursework - PhD seminar courses - QM PhD courses - General managerial skills courses</p> <p>(2) Attend research seminars</p> <p>(3) TA appointment (if needed)</p>	<p>(1) Coursework - PhD seminar courses - QM PhD courses - General managerial skills courses</p> <p>(2) TA appointment (if needed)</p> <p>(3) Sit in QM teacher course</p> <p>(4) Attend research seminars</p>	<p>(1) Two-year summer research - Presentation (in November) - Submission (by December 31)</p> <p>(2) TA appointment (if needed)</p> <p>(3) Sit in distinguished teacher course</p> <p>(4) Teaching (if available)</p>	<p>(1) Research work following proposal</p> <p>(2) Submit research paper(s)</p> <p>(3) Present paper(s) at conference(s)</p> <p>(4) Prepare for the job market - Job market interviews - Conference(s) - Campus visits</p>
Spring	<p>(1) Coursework - PhD seminar courses - QM PhD courses - General managerial skills courses</p> <p>(2) Attend research seminars</p> <p>(3) TA appointment (if needed)</p> <p>(4) Discuss with faculty for research</p>	<p>(1) Coursework - PhD seminar courses - QM PhD courses - General managerial skills courses</p> <p>(2) Discuss with faculty for research</p> <p>(3) Submit Plan of Study document</p> <p>(4) TA appointment (if needed)</p> <p>(5) Attend research seminars</p> <p>(6) Study assigned papers for prelim.</p>	<p>(1) Develop dissertation proposal</p> <p>(2) Research work following proposal</p> <p>(3) Conference abstract submission</p> <p>(4) TA appointment (if needed)</p> <p>(5) Teaching (if available)</p>	<p>(1) Research work following proposal</p> <p>(2) Job market interviews - Campus visits</p> <p>(3) Finish dissertation</p>
Summer	<p>(1) Coursework - QM PhD courses</p> <p>(2) Summer research work</p> <p>(3) First year evaluation</p>	<p>(1) Summer research work</p> <p>(2) Preliminary examination</p> <p>(3) Second year evaluation (Decision on qualification and continuation)</p>	<p>(1) Research work following proposal</p> <p>(2) Prepare for job market paper</p> <p>(3) Third year evaluation</p>	<p>(1) Dissertation defense</p> <p>(2) Graduation</p>