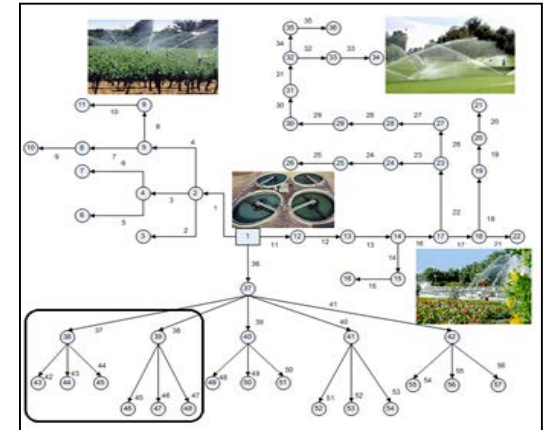# Operations Research

Department of Integrated Systems Engineering

The Ohio State University

Operations Research (OR) applies advanced analytical methods to help make better decisions. Employing techniques such as

- mathematical modeling,
- statistical analysis, and
- mathematical optimization

Operations research arrives at optimal or near-optimal solutions to complex decision-making problems.

The ISE Department at the Ohio State University has a premier graduate program in operations research. The research focus is both on

- methodology (data analytics, optimization, and stochastic processes)
- applications (cloud computing, cyber and homeland security, energy systems, logistics and supply chain, social networks, sustainable mobility, water resources management)

Up to 3 University and College Scholarships and Fellowships are available for first-year PhD students. To be considered, please complete your application by November 30th.

To be considered for Department Teaching and Research Assistantships and Scholarships, please complete your application by January 1st.

Operations Research Degree Programs

The ISE department at the Ohio State University offers two degree programs (MS and PhD) in OR:

1. **Master of Science (MS) in OR** builds fundamental OR skills with an emphasis on the application of these skills in practice

2. **Doctor of Philosophy (PhD) in OR** is academically rigorous with an emphasis on scholarly research and achievement. PhD students are prepared for academic placements and research-oriented positions in government and industry.

Graduates of the OR PhD program at the Ohio State University lead successful careers in:

- **Academia:**

Air Force Institute of Technology, Bowling Green State, Korean Advanced Institute of Science and Technology, National University of Singapore, University of Alabama, University of Ghana Business School

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Why Study Operations Research?

One of the Best Business Jobs[*]

Operations Research Analyst Ranked #2 Best Business Job
[*] Source: U.S. News and World Report

Increasing Job Opportunities[**]

Operations Research Analyst (increase 22% by 2018)
Management analyst (increase 24%)
Computer systems analyst (increase 20%)

[**] Source: Bureau of Labor Statistics

Graduates of the OR MS and PhD programs at the Ohio State University lead successful careers in:

- **Industry:** American Woodmark Co., Bell Labs, Flexis North America, General Motors, Goodyear, Honda, J.P. Morgan Chase, Lightning Bolt Solutions, Pacific Gas and Electric, Qualcomm, SABRE, Samsung
- **Government:** Battelle Memorial Institute, Center for Naval Research, the Coast Guard


INFORMS Student Chapter at OSU

The **Institute for Operations Research and the Management Sciences (INFORMS)** is the largest society in the world for professionals in the field OR, Management Science, and Analytics.

The **INFORMS Student Chapter at OSU** serves as a forum to forge intellectual connections with faculty, students, alumni, and professionals that lead to publications, job opportunities, consulting relationships, and internships.

INFORMS Student Chapter at OSU activities include:
- OSU INFORMS Lecture Series
- Volunteering in regional workshops and conferences
- Tutorials on software (e.g., LaTeX, MATLAB, Cplex)
- Social events (e.g., monthly happy hours, potlucks)
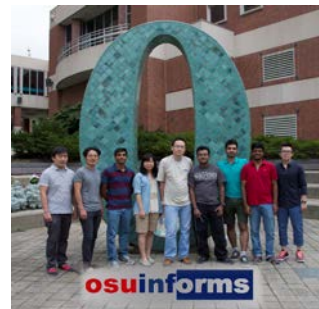
Student Demographics[*]

Female: 28%   PhD: 45%   MS: 55%

[*] As of 2018

Operations Research Graduate Curriculum

	Optimization	Stochastic Processes	Statistics
Fundamentals for M.S. Students	• ISE 5200 Linear Optimization • ISE 7250 Operations Research Models and Methods	• ISE 6300 Simulation for System Analytics and Decision-Making	• ISE 5110 Forecasting, Regression, and Design of Engineering Experiments
Additional Fundamentals for Ph.D. Students	• ISE 7200 Advanced Nonlinear Optimization	• ISE 7300 Stochastic Processes	
Elective Courses	• ISE 5220 Complementarity Modeling and Applications (in Spring 2015, this course was offered as ISE 5194 (32873 and 32874)) • ISE 6220 Network Optimization • ISE 6290 Stochastic Optimization • ISE 7210 Large-Scale Optimization • ISE 7230 Integer Optimization • ISE 7420 Sequencing and Scheduling	• ISE 5350 Probabilistic Models and Methods in Operations Research (in Spring 2015, this course was offered as ISE 5194 (32871 and 32872)) • ISE 7100 Advanced Simulation	
Special Topics[1]	• ISE 8299 Special Topics in Optimization Topics can include: • Heuristics and Global Optimization • Graphs and Networks	• ISE 8399 Special Topics in Stochastic Processes Topics can include: • Queuing Networks • Stochastic Control • Electricity Markets • Energy Systems • Water Management	
Others[2]	• ISE 5410 Quantitative Methods in Production and Distribution Logistics • ISE 5830 Decision Analysis • ISE 5840 Market Engineering		

[1]Special Topics courses may be taken more than once and are subject to adviser and instructor approval.
[2]This list is illustrative.

Prior to admission, students intent on graduate studies in operations research should be proficient in the following areas:[3]

Vector calculus	Optimization
Calculus-based probability	Probability-based statistics
Linear algebra	Computer programming (e.g., C, C++, Java)

All OR Graduate Students must satisfy degree requirements defined in the <u>Industrial and Systems Engineering Graduate Student Handbook</u>. Specific requirements for OR students include "OR Fundamentals," "Non-OR ISE Fundamentals," and a course sequence in an application area, as indicated in the table below.

OR Fundamentals	Non-OR ISE Fundamentals	Application Area	Special Topics
M.S. Students			

5110, 5200, 6300, 7250, 7883 (2 semesters)	One 5000-level or higher ISE course in human factors or manufacturing engineering, subject to approval of the advisory committee	At least 3 units in an application, subject to approval of the advisory committee	M.S. Students must do one of the following:
			1) M.S. thesis
			2) Non-thesis option. In this case, students must pass an M.S. exit exam. This requirement can be fulfilled in two ways:
			    2.1) pass the OR M.S. exit exam
			    2.2) earn a B or higher in a 6000 or higher-level course in operations research (in addition to OR fundamentals for MS students) that is at least 3 units and has a project requirement
			    (see next page for details for these 2 options)

Ph.D. Students			
5110, 5200, 6300, 7200, 7250, 7300, 7883 (3 semesters)	One 5000-level or higher ISE course in human factors or manufacturing engineering, subject to approval of the advisory committee	At least 6 units in an application, subject to approval of the advisory committee	Dedicated OR Ph.D. students are expected to take as many elective and special topics courses as their schedules permit

During the first three semesters, Ph.D. students are expected to identify a potential research topic of interest and a faculty adviser. Undertaking independent study (ISE 6193 or ISE 7193) is the recommended method of accomplishing this.

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[3]Students without evidence of this material on their transcripts will have to demonstrate proficiency with the subject matter. This can be accomplished via appropriate coursework, at either the undergraduate or graduate level, to be determined in consultation with the academic adviser.

2.1) M.S. Exit Examination for ISE M.S. students studying operations research

1. The M.S. Exit Examination is administered annually during the week after Spring final complete. Any ISE graduate student who achieves an overall GPA (including all courses taken at OSU) of 3.00 is eligible to take the exam. Those students who are planning to graduate in Fall should take the exam in the preceding Spring semester. The process to sign-up for the exam will be announced during Spring semester. Students intending to take the exam must sign-up before the announced deadline, so there is sufficient time to check that the grade eligibility requirement is satisfied.
2. The intent of the exam is to verify that students are sufficiently well grounded in the "fundamentals of OR." For example, the exam might cover the following topics:
   Optimization: Integer and Linear Programming Formulations and Solution Methods; Linear Programming Theory and Duality; Complexity Theory; Convexity
   Stochastic Processes: Random Variables; Probability Distributions; Conditional Probability and Expectations; Markov Chains; Random Number Generation; Simulation Theory
   Statistics: Parametric and Non-Parametric Hypothesis Testing; Distribution Fitting; Regression
3. After the exams have been completed, the OR Faculty meet to discuss each student's performance on the exam and performance in classes taken. Based on this, the faculty determine whether each student has "passed" or "failed" the examination.
4. A student who has failed the examination, may be deemed eligible to retake it. Students who are deemed eligible to retake the exam must do so the next time that it is offered. No student will be eligible to take the exam more than twice.

2.2) A project-based operations research course with at least a B grade

1. Student must earn a B or higher in a 6000 or higher-level course in operations research. This course must have a project requirement, and it must be at least 3 units.
2. This course cannot be any of the OR fundamentals for M.S. students (ISE 6300, 7250).
3. This course cannot be counted toward any of the other minimal degree requirements. For instance, this course cannot be the same as the only 3-unit course that is counted toward an application course. It cannot be a non-OR ISE course as well; observe that such a course is a non-OR course.
4. The project must be done as an individual.
5. Possible courses include (if they have a project requirement when offered):
   - ISE 6220 Network Optimization
   - ISE 6290 Stochastic Optimization
   - ISE 7100 Advanced Simulation
   - ISE 7210 Large-Scale Optimization
   - ISE 7230 Integer Optimization
   - ISE 7420 Sequencing and Scheduling
   - ISE 7300 Stochastic Processes
   - An independent study with a report at the end.
6. You may be asked to bring a copy of your project topic and report to make sure this requirement is fulfilled.

Both options 2.1 and 2.2 require a two-member committee for graduation by the graduate school. The first member of the committee should be the M.S. adviser. The second committee member is typically the professor who taught the project-based course in option 2.2, and the faculty coordinator for the OR M.S. Exit exam in option 2.1.

Qualifying Examination for ISE Ph.D. students studying operations research

1. Successful completion of the Ph.D. Qualifying Examination is a prerequisite for taking the Candidacy examination. Thus, students who do not pass the Qualifying Examination are not able pursue a Ph.D. in operations research.
2. The OR Ph.D. Qualifying Examination is administered annually during the week after Spring finals complete.
3. Any ISE graduate student who achieves a GPA of 3.30 or higher in the OR Fundamentals (ISE 5110, ISE 5200, ISE 6300, ISE 7200, ISE 7250, and ISE 7300) is eligible to take the exam. This GPA requirement pertains solely to courses taken at OSU. Students who have taken their "fundamentals" elsewhere are eligible to take the exam, provided that their OSU GPA in any remaining fundamentals courses taken at OSU is at least 3.30.
4. The intent of the exam is to verify that students are sufficiently well grounded in the "fundamentals of OR." For example, the exam might cover the following topics:
   Optimization: Integer, Linear, and Non-Linear Programming Formulations and Solution Methods; Linear and Non-Linear Programming Theory and Duality; Complexity Theory; Convexity
   Stochastic Processes: Random Variables; Probability Distributions; Conditional Probability and Expectations; Poisson Processes; Markov Chains; Random Number Generation; Simulation Theory; Basic Queuing Theory
   Statistics: Parametric and Non-Parametric Hypothesis Testing; Distribution Fitting; Regression
5. After the exams have been completed the OR Faculty meet to discuss each student's performance on the exam, performance in classes taken, and academic and research interests and goals. Based on this, the faculty determine whether or not each student has "passed" or "failed" the examination.
6. A student who has failed the examination, may be deemed eligible to retake it. Students who are deemed eligible to retake the exam must do so the next time that it is offered. No student will be eligible to take the exam more than twice.

Minor degree requirements

PhD students are required to complete 2 minors. Popular minors include:
- Economics
- Computer Science
- Mathematics
- Statistics