INDUSTRIAL AND OPERATIONS ENGINEERING, MASTER OF SCIENCE

Overview

Industrial and Operations Engineering is a rigorous program that combines theory and practice to empower students to be able to apply advanced methods in the solution of real-world problems. Graduates from this program will be able to apply industrial and operations engineering theoretical concepts and practical methodologies in the development of systems and processes for use in industry, government, and other settings.

The Master of Science in Industrial and Operations Engineering provides a student with a common core curriculum of graduate courses in statistics, data analytics, optimization, operations research, engineering economics, systems engineering, and mathematical modeling methods, coupled with advanced graduate courses in one of eight focus areas, and additional technical elective courses.

Some courses in the focus areas below have prerequisites outside of the core IOE requirements. It is the student's responsibility to fulfill those prerequisites, as needed, in order to enroll in such courses.

The focus areas are:

- Financial Systems
- Energy and Environmental Systems
- Healthcare Engineering
- Human Factors and Ergonomics
- Manufacturing and Facilities
- Operations Research and Intelligent Systems
- Quality Engineering and Applied Statistics
- Transportation, Networks, and Supply Chains

Admission Requirements

Applicants (degree-seeking and special students) must meet the general requirements for admission to graduate study, as outlined in the Admission Requirements (https://e-catalogue.jhu.edu/engineering/engineering-professionals/admission-requirements/) section. The applicant's prior education must include the following prerequisites:

1. single variable and multivariable calculus (sometimes called calculus I, II, and III) and at least one mathematics course beyond multivariable calculus (such as advanced calculus, differential equations, or linear algebra); and
2. at least one semester/term (or equivalent employment-based proficiency) in a programming language (e.g., C, C++, FORTRAN, Java, Python, R, or MATLAB).

Applicants whose prior education does not include the prerequisites listed above may still enroll under provisional status, followed by full admission once they have completed the missing prerequisites. Missing prerequisites may be completed with Johns Hopkins Engineering or, with approval, at another regionally accredited institution. In addition to these requirements, a detailed work résumé, statement of purpose, and transcripts from all college studies must be submitted. Admitted students typically have earned a grade point average of at least 3.0 on a 4.0 scale (B or above) in the latter half of their undergraduate studies. When reviewing an application, the candidate's academic and professional background will be considered.

Program Requirements

Ten courses with a minimum of 30 approved credit hours must be completed within five years. The curriculum consists of six core courses (18 credits) and four courses (12 credits) from one of the eight focus areas. One or more core courses can be waived by the student's advisor if a student has received an A or B in equivalent graduate courses. In this case, the student may replace the waived core courses with the same number of other graduate Industrial and Operations Engineering courses and may take these courses after all remaining core course requirements have been satisfied. Only one C-range grade (C+, C, or C–) can count toward the master's degree. Core courses and focus area offerings may be subject to change, in alignment with program objectives, with program committee approval.

Courses

Core Courses

Code	Title	Credits
Select five (5) courses (15 credits):		**Credits**
EN.625.603	Statistical Methods and Data Analysis	3
EN.625.615	Introduction to Optimization	3
EN.625.623	Introduction to Operations Research: Probabilistic Models	3
or EN.625.633	Monte Carlo Methods	
EN.645.631	Introduction to Model Based Systems Engineering	3
EN.715.641	Engineering Economics	3
Select one (1) Analytical Methods for Math Modeling Course (3 credits)		
Select one (1) 700#level course from the Applied and Computational Mathematics, Computer Science, or other program that may count towards the required foundational course in advanced analytical methods for math modeling. The course is required to be mathematically based and have at least a calculus prerequisite. Courses outside of ACM (625.7xx) or CS (605.7xx) need to be approved by an advisor.		3

Focus Areas

Four (4) elective courses (12 credits) must be selected from one of the eight focus areas. Two (2) of the four courses must be at the 700 level.

- Financial Systems (p. 2)
- Energy and Environmental Systems (p. 2)
- Healthcare Engineering (p. 2)
- Human Factors and Ergonomics (p. 2)
- Manufacturing and Facilities (p. 2)
- Operations Research and Intelligent Systems (p. 3)
- Quality Engineering and Applied Statistics (p. 3)
- Transportation, Networks, and Supply Chains (p. 3)

Note: The Focus Area courses below must be separate from those taken towards the six foundational courses. For example, if 625.633 Monte Carlo Methods was taken as one of the foundational courses (as part of the choice between 625.623 Introduction to Operations Research or 625.633), then it may not also be counted towards a focus area. In addition, the required 700#level course in advanced analytical methods

for math modeling (part of the six foundational courses) cannot also be counted towards a focus area.

financial systems focus area

Code	Title	Credits
Courses		**Credits**
EN.555.644	Introduction to Financial Derivatives	3
EN.555.645	Interest Rate and Credit Derivatives	3
EN.555.647	Quantitative Portfolio Theory & Performance Analysis	3
EN.555.648	Financial Engineering and Structured Products	3
EN.625.633	Monte Carlo Methods	3
EN.625.641	Mathematics of Finance	3
EN.625.642	Mathematics of Risk, Options, and Financial Derivatives	3
EN.625.695	Time Series Analysis	3
EN.625.714	Introductory Stochastic Differential Equations with Applications	3
EN.625.721	Probability and Stochastic Processes I	3
EN.625.722	Probability and Stochastic Processes II	3
EN.625.740	Data Mining	3
EN.625.741	Game Theory	3

Energy and environmental systems focus area

Code	Title	Credits
Courses		**Credits**
EN.575.604	Principles of Environmental Engineering	3
EN.575.605	Principles of Water and Wastewater Treatment	3
EN.575.619	Principles of Toxicology, Risk Assessment & Management	3
EN.575.623	Industrial Processes and Pollution Prevention	3
EN.575.706	Biological Processes for Water & Wastewater Treatment	3
EN.575.762	Resilience of Complex Systems	3
EN.575.771	Data Analytics in Environmental Health and Engineering	3
EN.615.621	Electric Power Principles	3
EN.615.648	Alternate Energy Technology	3
EN.615.731	Photovoltaic & Solar Thermal Energy Conversion	3
EN.615.761	Intro To Oceanography	3
EN.615.775	Physics of Climate	3

healthcare engineering focus area

Code	Title	Credits
Courses		**Credits**
EN.585.617	Rehabilitation Engineering	3
EN.585.725	Biomedical Engineering Practice and Innovation	3
EN.585.770	Global Health Engineering	3
EN.625.651	Mathematical Models in Healthcare	3
EN.645.650	Foundations of Human Systems Engineering	3
EN.645.755	Methods in Human-System Performance Measurement and Analysis	3
EN.655.662	Intro to Healthcare Systems Engineering	3
EN.655.667	Management of Healthcare Systems Projects	3
EN.655.771	Healthcare Systems	3

human factors and ergonomics focus area

Code	Title	Credits
Courses		**Credits**
PH.182.613	Exposure Assessment Techniques for Health Risk Management [1]	3
PH.182.615	Airborne Particles [1]	4
PH.182.621	Introduction to Ergonomics [1]	4
PH.182.622	Ventilation and Hazard Control [1]	4
PH.182.625	Principles of Occupational and Environmental Hygiene [1]	4
PH.182.637	Noise and Other Physical Agents in the Environment [1]	4
PH.188.680	Fundamentals of Occupational Health [1]	3
PH.188.681	Onsite Evaluation of Workplace and Occupational Health Programs [1]	5
EN.525.786	Human Robotics Interaction	3
EN.535.782	Haptic Applications	3
EN.585.725	Biomedical Engineering Practice and Innovation	3
EN.585.732	Advanced Signal Processing for Biomedical Engineers	3
EN.645.650	Foundations of Human Systems Engineering	3

[1] Classes numbered 182.xxx and 188.xxx are on the quarter system through the Johns Hopkins School of Public Health (JHSPH). The JHU credit equivalence is 1.5 quarter credits = 1 semester credit. IOE students taking courses through the JHSPH will need to ensure that they achieve the equivalent of at least 30 semester credit hours to fulfill the requirements for the Master of Science.

manufacturing and facilities focus area

Code	Title	Credits
Courses		**Credits**
EN.515.635	Mechanical Properties of Materials	3
EN.515.655	Metal Additive Manufacturing	3
EN.515.658	Design for Additive Manufacturing	3
EN.535.603	Applied Optimal Control	3
EN.535.618	Fabricatology - Advanced Materials Processing	3
EN.535.622	Robot Motion Planning	3
EN.535.630	Kinematics & Dynamics of Robots	3
EN.535.659	Manufacturing Systems Analysis	3
EN.535.672	Advanced Manufacturing Systems	3
EN.535.727	Advanced Machine Design	3
EN.535.737	Multiscale Modeling and Simulation of Mechanical Systems	3
EN.605.636	Autonomic Computing	3
EN.605.716	Modeling and Simulation of Complex Systems	3
EN.625.734	Queuing Theory with Applications to Computer Science	3
EN.635.673	Protecting Critical Infrastructure Against Cyber Attacks	3
EN.645.755	Methods in Human-System Performance Measurement and Analysis	3

operations research and intelligent systems focus area

Code	Title	Credits
Courses		**Credits**
EN.525.733	Deep Learning for Computer Vision	3
EN.605.645	Artificial Intelligence	3
EN.605.646	Natural Language Processing	3
EN.605.649	Principles and Methods in Machine Learning	3
EN.605.740	Machine Learning: Deep Learning	3
EN.605.742	Deep Neural Networks	3
EN.605.745	Reasoning Under Uncertainty	3
EN.605.746	Advanced Machine Learning	3
EN.605.747	Evolutionary and Swarm Intelligence	3
EN.625.618	Discrete Hybrid Optimization	3
EN.625.623	Introduction to Operations Research: Probabilistic Models	3
EN.625.624	Network Models and Analysis	3
EN.625.633	Monte Carlo Methods	3
EN.625.638	Foundations of Neural Networks	3
EN.625.661	Statistical Models and Regression	3
EN.625.662	Design and Analysis of Experiments	3
EN.625.663	Multivariate Statistics and Stochastic Analysis	3
EN.625.664	Computational Statistics	3
EN.625.665	Bayesian Statistics	3
EN.625.694	Introduction to Convexity	3
EN.625.721	Probability and Stochastic Processes I	3
EN.625.722	Probability and Stochastic Processes II	3
EN.625.734	Queuing Theory with Applications to Computer Science	3
EN.625.736	Combinatorial Optimization	3
EN.625.740	Data Mining	3
EN.625.741	Game Theory	3
EN.625.743	Stochastic Optimization & Control	3
EN.625.744	Modeling, Simulation, and Monte Carlo	3
EN.685.621	Algorithms for Data Science	3

quality engineering and applied statistics focus area

Code	Title	Credits
Courses		**Credits**
EN.525.778	Design for Reliability, Testability, and Quality Assurance	3
EN.595.742	Quality Management in Technical Organizations	3
EN.605.662	Data Visualization	3
EN.605.745	Reasoning Under Uncertainty	3
EN.625.633	Monte Carlo Methods	3
EN.625.638	Foundations of Neural Networks	3
EN.625.661	Statistical Models and Regression	3
EN.625.662	Design and Analysis of Experiments	3
EN.625.663	Multivariate Statistics and Stochastic Analysis	3
EN.625.664	Computational Statistics	3
EN.625.665	Bayesian Statistics	3
EN.625.695	Time Series Analysis	3
EN.625.714	Introductory Stochastic Differential Equations with Applications	3
EN.625.725	Theory Of Statistics I	3
EN.625.726	Theory of Statistics II	3
EN.625.728	Theory of Probability	3
EN.625.734	Queuing Theory with Applications to Computer Science	3
EN.625.740	Data Mining	3
EN.625.741	Game Theory	3
EN.625.743	Stochastic Optimization & Control	3
EN.625.744	Modeling, Simulation, and Monte Carlo	3
EN.675.713	Fault Management and Autonomy: Improving Spacecraft Survivability	3
EN.675.761	Reliability Engineering and Analysis for Space Missions	3
EN.675.772	Verification and Validation of Space Systems	3
EN.685.621	Algorithms for Data Science	3
EN.685.648	Data Science	3
EN.685.652	Data Engineering Principles and Practice	3

transportation, networks, and supply chains focus area

Code	Title	Credits
Courses		**Credits**
EN.525.761	Wireless and Wireline Network Integration	3
EN.575.608	Optimization Methods for Public Decision Making	3
EN.575.734	Smart Growth Strategies for Sustainable Cities	3
EN.575.738	Transportation, Innovation, and Climate Change	3
EN.575.762	Resilience of Complex Systems	3
EN.595.701	Product and Supply Chain Management for Technical Professionals	3
EN.605.671	Principles of Data Communications Networks	3
EN.605.779	Network Design and Performance Analysis	3
EN.625.624	Network Models and Analysis	3
EN.635.611	Principles of Network Engineering	3
EN.635.711	Advanced Topics in Network Engineering	3
EN.695.721	Network Security	3

Please refer to the course schedule (ep.jhu.edu/schedule (https://apps.ep.jhu.edu/schedule/search/)) published each term for exact dates, times, locations, fees, and instructors.

Learning Outcomes

By the end of this program, students will be able to:

- Develop a systems description or design for real-world systems and processes
- Strengthen technical skills in mathematical modeling of systems and processes.
- Articulate the requirements, drivers, functions, components, interdependencies, risks and quality factors for various systems and processes
- Lead the development of new industrial and operations engineering algorithms and features into systems and processes
- Enhance skills in a chosen technical focus area