MECHANICAL ENGINEERING, MASTER OF SCIENCE

Mechanical Engineering, Master of Science

A focus area must be chosen for this program.

Admission Requirements

Applicants 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 a bachelor's degree in Mechanical Engineering or a closely related technical discipline. Applicant's prior education should include the following prerequisites:

1. Three semesters of collage calculus (Calculus I, II and III)
2. Two semesters of collage physics (Physics I and II)
3. A course or practical knowledge of a programing language (such as Python, Matlab, or C++)

Applicants whose prior education does not include the prerequisites listed above may still enroll under provisional status, followed by full admission status once they have completed the missing prerequisites with a letter grade B- or higher. Missing prerequisites may be completed with Johns Hopkins Engineering or at another regionally accredited institution.

Enrolled students typically have earned a grade point average of at least 3.3 on a 4.0 scale (B+ or above) in their undergraduate studies, though this is not a requirement for admission, nor is it a guarantee. Transcripts from all college studies must be submitted. When reviewing an application, the candidate's academic and professional background will be considered in its totality, and decisions are made on a case-by-case basis. It is strongly advised that applicants submit a maximum of two page curriculum vitae listing their relevant professional background.

Program Requirements

Students can choose one of two options to fulfill their Master's degree requirements: the "All-Course" option or the "Thesis" option. The requirements for both options are summarized below.

All-Course Option:

Students completing the "all-course" option must take a coordinated sequence of ten courses. All courses must be completed within five years from the start of the student's first class. Students are required to choose a focus area to follow. The focus area selected does not appear as an official designation on the student transcript. The curriculum consists of one core course in mathematics, two core courses from Group 1 and three other courses from Group 2 of the student's chosen focus area, and four technical electives. At least two of the four electives must be from a core engineering discipline, and at most two can be chosen from the Engineering Management, Systems Engineering, Space Systems Engineering, Information Systems Engineering, Healthcare Systems Engineering, Cybersecurity, Financial Mathematics, Occupational and Environmental Hygiene, or Environmental Planning and Management programs.

One of the four elective courses can be substituted for EN.535.820 - Masters Graduate Research. This course is intended to give a research experience to those pursuing an "all-course" master's degree. The research must be approved by the student's research supervisor, which can be an academic advisor, a current full-time faculty member at the Department of Mechanical Engineering at Johns Hopkins University, a research staff member at the Johns Hopkins University Applied Physics Laboratory, or an active instructor affiliated with one of the Engineering for Professionals programs. Prior written approval of the advisor and the program chair must be received before enrolling in this course.

Courses from the full-time program (EN.530.XXX) may be substituted for a relevant requirement with advisor approval. One computationally-oriented course is strongly recommended and can serve as a technical elective or as a substitute to one of the three courses required from Group 2 of the student's chosen focus area. Only one C-range grade (C+, C, or C–) can count toward the master's degree. All course selections outside of the Mechanical Engineering program are subject to advisor approval.

Thesis Option:

Students completing the "thesis" option must take a coordinated sequence of eight courses and prepare and submit a Master's thesis. All requirements should be completed within five years. Students are required to choose a focus area to follow. The focus area selected does not appear as an official designation on the student transcript. The curriculum consists of one core course in mathematics, two core courses from those listed in Group 1 and three courses from those listed in Group 2 of the student's chosen focus area, two technical electives, and a thesis. The thesis should expand the body of theoretical or applied knowledge in the field of the student's chosen focus area. At least one of the two electives must be from a core engineering discipline, and at most one can be chosen from the Engineering Management, Systems Engineering, Space Systems Engineering, Information Systems Engineering, Healthcare Systems Engineering, Cybersecurity, Financial Mathematics, Occupational and Environmental Hygiene, or Environmental Planning and Management programs. Only one C-range grade (C+, C, or C–) can count toward the master's degree. All course selections outside of the Mechanical Engineering program are subject to advisor approval.

Students electing to choose the thesis option should get prior written approval from both their academic advisor and the program chair and must work with an approved research advisor. The research advisor can be any current full-time faculty member at the Department of Mechanical Engineering at Johns Hopkins University. Prior written approval should be secured from the program chair if the research advisor will be a research staff member at the Johns Hopkins University Applied Physics Laboratory or an active instructor affiliated with the Engineering for Professionals Mechanical Engineering program. An electronic version of the master thesis should be delivered to the Milton S. Eisenhower (MSE) library after its approval by the thesis committee. The thesis committee consists of the thesis research advisor and one other member who is an expert in the research area of the thesis and to be selected by the program chair. The research work should generally start after the student finishes all the course requirements for their chosen focus area and should not take more than 3 consecutive semesters. While working on the thesis, students must enroll in the two-course sequence EN.535.820 - Master's Graduate Research and EN.535.821 - Master's Thesis Writing, where the research advisor serves as the instructor for

both. The prerequisite for these courses is the completion of all course requirements in the student's focus area and the approval of the program chair. The approval of the program chair follows the submission of a research proposal by the student that is approved by their research advisor. Hence, the student must contact a research advisor and discuss potential research topics of interest to both parties, conduct a literature survey, and present a maximum of three-page research proposal to be approved by the program chair. The latest a proposal can be submitted for consideration is during the third to last semester of the five-year limit.

Courses from the full-time program (EN.530.XXX) may substitute a relevant requirement with the advisor approval. One computationally-oriented course is strongly recommended and can serve as a technical elective or as a substitute to one of the three courses required from Group 2 of the student's chosen focus area. Only one C-range grade (C +, C, or C–) can count toward the master's degree. All course selections outside of the Mechanical Engineering program are subject to advisor approval.

Program Course Requirements

Code	Title	Credits
Core Course		
EN.535.641	Mathematical Methods For Engineers [1]	3
Recommended (At least one of these computationally-oriented courses is strongly recommended in place of one of the three required courses from Group 2)		
EN.535.609	Topics in Data Analysis	3
EN.535.610	Computational Methods of Analysis	3
EN.535.742	Applied Machine Learning for Mechanical Engineers	3
EN.535.766	Numerical Methods	3
Focus Areas		
Select one of the following Focus Areas:		
Advanced Manufacturing (p. 2)		
Biomechanical Engineering (p. 2)		
Fluid Mechanics and Thermal Science (p. 3)		
Hypersonic Technologies (p. 3)		
Robotics, Dynamics, and Controls (p. 3)		
Solids/Mechanics of Materials (p. 4)		

[1] This course must be taken in the first semester of the student's program, unless the advisor explicitly allows the student to do otherwise.

Focus Area Courses

Students are required to choose one of six focus areas: Advanced Manufacturing, Biomechanical Engineering, Fluid Mechanics and Thermal Science, Hypersonic Technologies, Robotics, Dynamics, and Controls, and Solids/Mechanics of Materials. The focus area selected does not appear as an official designation on the student transcript. Each focus area has five required courses. Of these courses, at least two must be completed from Group 1. Post-master's certificate students are not limited to one focus area but can choose their courses among all the courses offered by the program.

ADVANCED MANUFACTURING

Study the automation of design and manufacturing systems including computer-aided design (CAD), computer-aided engineering (CAE), computer-aided manufacturing (CAM), and robotics. Understand the relationships between process machinery, process conditions, and material properties. Learn to design precision machines, instruments, and mechanisms through an understanding of gears, bearings, actuators, and sensors. Develop a clear understanding of positional repeatability and accuracy as well as sources of machine and instrumentation errors. Explore the latest manufacturing processes in high-tech industries.

Code	Title	Credits
Select five of the following of which two must be from Group 1:		
Group 1 (must select two)		
EN.535.628	Computer-Integrated Design and Manufacturing	3
EN.535.659	Manufacturing Systems Analysis	3
EN.535.660	Precision Mechanical Design	3
EN.535.673	Mechanized Assembly: Hardware and Algorithms	3
Group 2 (must select three)		
EN.515.601	Structure and Properties of Materials	3
EN.515.622	Micro and Nano Structured Materials & Devices	3
EN.515.655	Metal Additive Manufacturing	3
EN.515.658	Design for Additive Manufacturing	3
EN.515.661	Introduction to Polymer Science	3
EN.535.606	Advanced Strength Of Materials	3
EN.535.607	Mechanics of Solids and Structures: Theory and Applications I	3
EN.535.623	Intermediate Vibrations	3
EN.535.627	Computer-Aided Design	3
EN.535.633	Intermediate Heat Transfer	3
EN.535.638	Mechanical Packaging for Electronics Systems	3
EN.535.642	Control Systems for Mechanical Engineering Applications	3
EN.535.672	Advanced Manufacturing Systems	3
EN.535.684	Modern Polymeric Materials	3
EN.535.720	Mechanics of Composite Materials and Structures	3

BIOMECHANICAL ENGINEERING

Study the human body, modeled as a mechanical system. Apply fundamental mechanical engineering principles to explore the body's structure and functions. Use deformable solid mechanics to study bone and soft tissues, fluid mechanics in exploring biofluidics, and statics and dynamics in musculoskeletal biomechanics applications. Learn about the biocompatibility of metallic, ceramic, polymeric, and even other biological materials that come in contact with tissue and biological fluids. Study biomechanical sensors and signals, the design of orthopedic implants, the principles of joint reconstruction, and emerging biomechanics frontiers.

Code	Title	Credits
Group 1 (must select two)		
EN.535.661	Biofluid Mechanics	3
EN.535.663	Biosolid Mechanics	3
EN.535.667	Biomechanics of Human Movement	3
EN.535.750	Biomechanics of the cell: From nano- and micro-mechanics to cell organization and function	3
EN.585.601	Physiology for Applied Biomedical Engineering I	3
EN.585.631	Introduction to Biomechanics	3
Group 2 (must select three)		
EN.515.606	Chemical and Biological Properties of Materials	3

EN.525.786	Human Robotics Interaction	3
EN.535.607	Mechanics of Solids and Structures: Theory and Applications I	3
EN.535.720	Mechanics of Composite Materials and Structures	3
EN.585.631	Introduction to Biomechanics	3
EN.585.708	Biomaterials	3
EN.585.710	Biochemical Sensors	3
EN.585.720	Orthopedic Biomechanics	3
EN.585.726	Biomimetics in Biomedical Engineering	3
EN.585.729	Cell and Tissue Engineering	3
EN.585.747	Advances in Cardiovascular Medicine	3

FLUID MECHANICS AND THERMAL SCIENCE

Learn to solve practical engineering fluid flow problems. Examine laminar and turbulent flows, plus vorticity and circulation. Understand a variety of experimental methods. Study transient heat conduction from both free and forced convection, in external and internal flows. Learn to perform the tradeoffs studies associated with thermodynamic and head transfer systems that arise in power and refrigeration systems, electronics cooling, distillation columns, heat exchangers, and co-generation systems. Apply computational fluid dynamics (CFD) to an array of complex flow and heat transfer phenomena.

Code	Title	Credits
Group 1 (must select two)		
EN.515.602	Thermodynamics and Kinetics of Materials	3
EN.535.620	Fluid Dynamics I	3
EN.535.621	Intermediate Fluid Dynamics	3
EN.535.633	Intermediate Heat Transfer	3
EN.535.634	Applied Heat Transfer	3
EN.535.735	Computational Fluid Dynamics	3
EN.575.601	Fluid Mechanics	3
EN.615.761	Intro To Oceanography	3
Group 2 (must select three)		
EN.515.622	Micro and Nano Structured Materials & Devices	3
EN.535.614	Fundamentals of Acoustics	3
EN.535.625	Turbulence	3
EN.535.652	Thermal Systems Design and Analysis	3
EN.535.661	Biofluid Mechanics	3
EN.535.662	Energy and Environment	3
EN.535.670	Advanced Aerodynamics	3
EN.535.737	Multiscale Modeling and Simulation of Mechanical Systems	3
EN.535.773	Acoustical Oceanography	3
EN.565.680	Marine Geotechnical Engineering	3

HYPERSONIC TECHNOLOGIES

Study the complex engineering and physics challenges associated with hypersonic flight (speeds over Mach 5.0). Learn about emerging hypersonic technologies, the governing fundamental physics of hypersonic flight, analysis approach, and how to design new and advanced hypersonic vehicles.

Code	Title	Credits
Group 1 (must select two)		
EN.535.608	Hypersonic Technologies and Systems	3
EN.535.752	Advanced Flight Dynamics and Control of Aerospace Vehicles	3
Group 2 (must select three)		
EN.535.620	Fluid Dynamics I	3
EN.535.627	Computer-Aided Design	3
EN.535.633	Intermediate Heat Transfer	3
EN.535.634	Applied Heat Transfer	3
EN.535.670	Advanced Aerodynamics	3
EN.535.735	Computational Fluid Dynamics	3
EN.575.601	Fluid Mechanics	3

ROBOTICS, DYNAMICS, AND CONTROLS

Study an array of aspects of robot motion planning including both rigid and compliant motion, coordinated motion, error detection and recovery, and motion in an unknown environment. Analyze the kinematics and dynamics of robotic manipulators. Apply classical control systems to mechanical engineering applications that span mechanical, electrical, fluid-flow, and process control systems. Develop an understanding of advanced control theory that includes reinforcement learning, also known as artificial intelligence and machine learning.

Code	Title	Credits
Group 1 (must select two)		
EN.525.609	Continuous Control Systems	3
EN.525.610	Microprocessors for Robotic Systems	3
EN.525.626	Feedback Control in Biological Signaling Pathways	3
EN.525.645	Modern Navigation Systems	3
EN.525.661	UAV Systems and Control	3
EN.525.777	Control System Design Methods	3
EN.525.786	Human Robotics Interaction	3
EN.535.622	Robot Motion Planning	3
EN.535.630	Kinematics & Dynamics of Robots	3
EN.535.642	Control Systems for Mechanical Engineering Applications	3
EN.535.724	Dynamics of Robots and Spacecraft	3
EN.535.752	Advanced Flight Dynamics and Control of Aerospace Vehicles	3
EN.605.613	Introduction to Robotics	3
EN.605.716	Modeling and Simulation of Complex Systems	3
Group 2 (must select three)		
EN.535.603	Applied Optimal Control	3
EN.535.612	Intermediate Dynamics	3
EN.535.623	Intermediate Vibrations	3
EN.535.627	Computer-Aided Design	3
EN.535.635	Introduction to Mechatronics	3
EN.535.638	Mechanical Packaging for Electronics Systems	3
EN.535.645	Digital Control and Systems Applications	3
EN.535.659	Manufacturing Systems Analysis	3
EN.535.660	Precision Mechanical Design	3
EN.535.673	Mechanized Assembly: Hardware and Algorithms	3
EN.535.726	Robot Control	3
EN.535.741	Optimal Control and Reinforcement Learning	3
EN.535.782	Haptic Applications	3

SOLIDS/MECHANICS OF MATERIALS

Study the deformation and failure of mechanical structures as well as the different classes of engineering materials. Perform tradeoff studies based upon design criteria including strength, toughness, corrosion resistance, manufacturability, and failure. Learn to use material properties to explore stress and strain in 3D, for both elastic and inelastic material behavior. Study transient and forced vibration of multi degree-of-freedom systems and incorporating vibration isolation. Learn to use finite element analysis as an extension of classical methods, performing an array of simulations that include linear and nonlinear structural, modal, buckling, random vibration, and even generative design analyses.

Code	Title	Credits
Group 1 (must select two)		
EN.535.606	Advanced Strength Of Materials	3
EN.535.607	Mechanics of Solids and Structures: Theory and Applications I	3
EN.535.623	Intermediate Vibrations	3
EN.535.632	Applied Finite Elements	3
EN.535.731	Engineering Materials: Properties and Selection	3
Group 2 (must select three)		
EN.515.601	Structure and Properties of Materials	3
EN.515.602	Thermodynamics and Kinetics of Materials	3
EN.515.606	Chemical and Biological Properties of Materials	3
EN.515.611	Computational Molecular Dynamics	3
EN.515.617	Nanomaterials	3
EN.515.622	Micro and Nano Structured Materials & Devices	3
EN.515.627	Chemistry of Nanomaterials	3
EN.515.655	Metal Additive Manufacturing	3
EN.515.658	Design for Additive Manufacturing	3
EN.515.661	Introduction to Polymer Science	3
EN.525.606	Electronic Materials	3
EN.535.612	Intermediate Dynamics	3
EN.535.618	Fabricatology - Advanced Materials Processing	3
EN.535.627	Computer-Aided Design	3
EN.535.643	Plasticity	3
EN.535.660	Precision Mechanical Design	3
EN.535.663	Biosolid Mechanics	3
EN.535.684	Modern Polymeric Materials	3
EN.535.706	Mechanics of Solids and Structures: Theory and Applications II	3
EN.535.711	Symmetries of Crystalline Solids	3
EN.535.720	Mechanics of Composite Materials and Structures	3
EN.535.732	Fatigue and Fracture of Materials	3
EN.535.748	Stress Waves, Impacts and Shockwaves	3
EN.565.604	Structural Mechanics	3
EN.565.680	Marine Geotechnical Engineering	3
EN.565.682	Design of Ocean Structures	3
EN.565.731	Structural Dynamics	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.