MECHANICAL ENGINEERING

Department Website: Mechanical Engineering (https://www.gonzaga.edu/school-of-engineering-applied-science/degrees-and-programs/mechanical-engineering/)

Mechanical Engineering is a branch of engineering that encompasses the study of forces, motion, energy, materials, manufacturing, and design in order to apply them to the creation of mechanical devices and systems that serve society (e.g., engines, refrigerators, machines, tools, etc.). This is accomplished through a process of problem description, creative idea generation, design, analysis, judgment, planning, and production that typically involves a host of professionals who may all have been educated as mechanical engineers. For example, mechanical engineers may be involved in product design, analysis, and testing, in developing manufacturing processes, in defining product requirements and trouble-shooting customer problems, in project management, and in research and education.

The profession serves many diverse fields and industries such as the aerospace, pharmaceutical, automotive, biomedical engineering, and power generation industries, to name just a few. In fact, any device or system that involves energy or movement probably involved one or more mechanical engineers in its creation. Some exciting, rapidly developing fields and emerging technologies of interest to mechanical engineers include fuel cells (the use of chemical fuel and an oxidant to directly produce electricity), rapid prototyping (the use of computer-controlled machines to fabricate complete objects in one step directly from computer models), mechatronics (the integration of mechanical systems and electronic sensing and control), biomedical engineering (the application of engineering to problems in medicine and biology), nanoengineering (the creation of materials and devices at the nanometer level, i.e., at the atomic, molecular, or supramolecular levels), and MEMS (Microelectromechanical Systems-the integration of mechanical, chemical, and/or electronic systems at the chip level).

The Department of Mechanical Engineering at Gonzaga University develops men and women who are both competent engineers and educated, responsible human beings. The development of these two characteristics in students is affected by course work from both the liberal arts and the profession. Thus, these two aspects are interwoven, being a single, integrated fabric having many threads contributed by many curricula. This synthesis is expressed by the engineering program educational objectives that are listed in the School of Engineering and Applied Science section of this catalog, and by the Gonzaga University Mission Statement that may be found at the beginning of the catalog.

Diversity of opportunity and professional breadth are hallmarks of the mechanical engineering profession. This translates into a need for a thorough grounding in a variety of mathematical, scientific, and engineering fundamentals. Thus, the Mechanical Engineering Program at Gonzaga University prepares the student in the areas of mathematics, chemistry, physics, mechanics, thermodynamics, fluid mechanics, heat transfer, materials, manufacturing, design, control theory, experimentation, and economics. These fundamentals are enhanced with exposure to important engineering tools such as: mathematical techniques; computer programming; computer applications including computer aided design (CAD), computer aided manufacturing (CAM), finite element analysis (FEA), and computational fluid dynamics (CFD); and the use of equipment, instruments, and software typically found in manufacturing and laboratory situations. Since teamwork is an essential aspect of the modern practice of mechanical engineering, the Mechanical Engineering Program gives considerable attention to building personal communication skills through team design projects, reports, and presentations. Furthermore, as a critical component of the program, all students engage in design courses beginning in their Freshman year, culminating in a two-semester capstone design experience in the Senior year. That experience typically entails requiring student design teams, led jointly by faculty and practicing engineers, to solve real industrial design problems. Finally, the degree requirements also include the opportunity for breadth as well as concentration in particular engineering applications through a group of technical electives taken in the senior year (the list of allowed technical electives is given below). The department also has a five-year plan available for students wishing to proceed at a slower pace or for those planning to add a minor in business or in a liberal arts subject such as physics, mathematics, music, or art. Information and a suggested course package is also available for students planning to enroll in the Gonzaga-in-Florence Engineering Semester program.

The following curriculum details the course requirements for each semester. In addition to these courses, all students must take the Fundamentals of Engineering Examination prior to graduation (see ENSC 400 Foundations of Engineering Exam in the Spring semester of the Senior year). Finally, students who follow a curriculum sequence other than that listed below should meet with their Academic Advisors at their first opportunity in order to resolve any scheduling conflicts that may arise due to off-schedule course availability and/or course pre- and co-requisite structure. In all cases, students must comply with the pre- and co-requisite requirements in order to be granted admission into courses.

The Bachelor of Science in Mechanical Engineering degree program is accredited by the Engineering Accreditation Commission of ABET, www.abet.org (http://www.abet.org/), under the General Program Criteria and the Mechanical and Similarly Named Engineering Programs Program Criteria.

Mechanical Engineering (BS) Major Program Requirements

Course	Title	Hours
First Year		
Fall		
CHEM 101	General Chemistry I	3
CHEM 101L	General Chemistry I Lab	1
DEPT 193	FYS	3
MATH 157	Calculus and Analytic Geometry I	4
COMM 100	Communication and Speech	3
PHIL 101	Reasoning	3
	Hours	**17**
Spring		
MATH 258	Calculus and Analytic Geometry II	4
PHYS 121	Physics I	4
PHYS 121L	Physics I Lab	1
MENG 291	Introduction to Mechanical Engineering Design	2
MENG 291L	Introduction to Mechanical Engineering Design Lab	1
ENGL 101	Writing	3
PHIL 201	Philosophy of Human Nature	3
	Hours	**18**
Second Year		
Fall		
ENSC 205	Statics	3
MENG 221	Materials Engineering	3
MATH 259	Calculus and Analytic Geometry III	4
PHYS 122	Physics II	4

PHYS 122L	Physics II Lab	1
ENSC 201	Programming for Engineers	3
	Hours	**18**
Spring		
ENSC 301	Mechanics of Materials I	3
ENSC 306	Dynamics	3
MATH 260	Ordinary Differential Equation	3
MATH 321	Statistics for Experimentalist	3
Ethics core requirement		3
RELI XXX World or Comparative Religion		3
	Hours	**18**
Third Year		
Fall		
MENG 321	Thermodynamics I	3
MENG 327 & 327L	Mechatronics and Mechatronics Lab	4
ENSC 371	Advanced Engineering Math	3
ENSC 352	Fluid Mechanics	3
ENSC 300	Engineering Economics [1]	1
RELI XXX Christianity and Catholic Traditions		3
	Hours	**17**
Spring		
ENSC 244	Computer Methods for Engineers	3
MENG 322	Thermodynamics II	3
MENG 330	Machine Design	3
MENG 341	Heat Transfer	3
MENG 301	Manufacturing Processes	2
MENG 362L	Thermal-Fluids Lab	1
MENG 301L	Manufacturing Processes Lab	1
	Hours	**16**
Fourth Year		
Fall		
ENSC 491	Senior Design Project I	2
MENG 461	System Dynamics and Control	3
Technical Elective		3
Technical Elective		3
1st Core Broadening Requirement: (History, Literature, Social and Behavioral Sci)		3
	Hours	**14**
Spring		
ENSC 400	Foundations of Engineering Exam [2]	0
ENSC 492	Senior Design Project II	3
Technical Elective		3
Technical Elective		3
DEPT 432	CIS:	3
2nd Core Broadening Requirement: (History, Literature, Social and Behavioral Sci)		3
	Hours	**15**
	Total Hours	**133**

[1] ENSC 300 Engineering Economics is waived under the following circumstances:

- **Students enrolled in the Hogan Entrepreneurial Leadership program:** ENSC 300 Engineering Economics is waived.
- **Students pursuing the General Business or Analytical Finance minor:** ENSC 300 Engineering Economics is waived after completing both (ECON 200 Economic Analysis or (ECON 201 Microeconomics and ECON 202 Macroeconomics)) and BFIN 320 Principles of Finance.
- **Students Pursuing the B.S. in Engineering and M.B.A. program:** ENSC 300 Engineering Economics is waived after completing both (ECON 200 Economic Analysis or (ECON 201 Microeconomics and ECON 202 Macroeconomics)) and BFIN 320 Principles of Finance.

The above courses are not intended to be options for the ENSC 300 Engineering Economics course. Hence, students who are not in one of the above programs are required to take ENSC 300 Engineering Economics. Also, students who comply with one of the above criteria must complete all of the courses required to waive ENSC 300 Engineering Economics prior to enrolling in any course for which ENSC 300 Engineering Economics is a pre-requisite.

[2] As part of the requirements of this course, students must show proof of having taken the Fundamentals of Engineering Exam, as administered by the NCEES (https://ncees.org/exams/fe-exam/).

Technical Electives

The courses used to satisfy the technical elective requirements must normally be selected from the following list. However, students may take other courses for technical elective credits but only with the prior approval of both the student's academic advisor and the chair of the Department of Mechanical Engineering. The actual technical elective courses offered from the list below varies from year to year and the department may on occasion offer one or more pre-approved technical elective courses that are not listed below. Courses other than MENG courses may have pre and/or co- requisites that are outside of the normal mechanical engineering curriculum. Students wishing to take these courses should plan well in advance in order to comply with all admission requirements prior to enrolling in the course.

Code	Title	Hours
CENG 301	Structural Analysis I	3
CENG 422	Structural Systems Design	3
EENG 412	Digital Control Systems	3
ENSC 481	Special Topics in Engineering (Design for Human Body)	1-6
ENSC 485	Special Topics in Engineering (Compliant Mechanisms)	1-6
ENSC 488	Special Topics in Engineering (Advanced Fluid Dynamics)	1-6
MENG 435	Applications in Vibrations	3
MENG 442	Advanced Heat Transfer	3
MENG 443	Combustion	3
MENG 445	Heating Vent and Air Condition	3
MENG 446	Energy Auditing	3
MENG 447	Advanced Energy Systems	3
MENG 451	Computational Dynamics	3
MENG 456	Design for Manufacturing	3
MENG 465	Introduction to Finite Element	3
MENG 467	Design with Polymers and Composites	3
MENG 468	Biomaterials and Biomechanical Engineering	3
MENG 477	Materials Selection for Design	3
MENG 478	Vehicle Dynamics	3
MENG 479	Tribology	3
PHYS 323	Statistical Mechanics	3
PHYS 452	Optics	3
PHYS 456	Biophysical Systems and Modeling	3
PHYS 453	Solid State Physics	3

Courses

MENG 193. First Year Seminar. (3 Credits)
The First-Year Seminar (FYS) introduces new Gonzaga students to the University, the Core Curriculum, and Gonzaga's Jesuit mission and heritage. While the seminars will be taught by faculty with expertise in particular disciplines, topics will be addressed in a way that illustrates approaches and methods of different academic disciplines. The seminar format of the course highlights the participatory character of university life, emphasizing that learning is an active, collegial process.

MENG 221. Materials Engineering. (3 Credits)
Introduction to the structure-property-processing relationship in metallic, ceramic, and polymeric materials, and to the atomic structure of materials and its influence on mechanical, electrical, and thermal properties. Students explore how alloying and thermomechanical processing modifies structure and changes the properties of materials.
Prerequisites: CHEM 101 with a minimum grade of D

MENG 291. Introduction to Mechanical Engineering Design. (2 Credits)
Introduction to mechanical engineering design, with emphasis on the creation and communication of design ideas. Students will learn construction geometry, visualization (orthographic views, isometric views, sectional views, etc.), hand sketching and drawing of initial designs, and how to create 2-D drawings. Detailed treatment of dimensioning and tolerancing. Strong focus on the design of basic machine elements in order to prepare the student for further coursework in machine design, and senior projects, as well as direct application in the practice of mechanical engineering. The design process, including, product specifications, product descriptions, and prototype fabrication will be introduced. To register for this course, each student is required to have a laptop that meets or exceeds the specifications of the School of Engineering and Applied Science (SEAS). Specifications are available on the SEAS web site.
Corequisites: MENG 291L

MENG 291L. Introduction to Mechanical Engineering Design Lab. (1 Credit)
Hands on use of SOLIDWORKS CAD system to create 3-D models and 2-D drawings of machinery elements and assemblies. Laboratory assignments are coordinated with lecture content from MENG 291. Student projects will focus on the creation of machinery elements and assemblies in a team environment.
Corequisites: MENG 291

MENG 301. Manufacturing Processes. (2 Credits)
Overview of manufacturing processes and how they influence design decisions. Emphasizes design for manufacturability, process comparison, and process specification.
Prerequisites: MENG 221 with a minimum grade of D
Corequisites: MENG 301L

MENG 301L. Manufacturing Processes Lab. (1 Credit)
Laboratory experiences with machine tools and manufacturing processes. Calculations and problem solving that reinforce lecture topics.
Corequisites: MENG 301

MENG 321. Thermodynamics I. (3 Credits)
The first and second laws of thermodynamics; thermophysical properties of matter, ideal gases and their mixtures; concept of entropy as applied to thermal systems.
Prerequisites: MATH 259 with a minimum grade of D

MENG 322. Thermodynamics II. (3 Credits)
Second Law analysis, power and refrigeration cycles, mixtures, combustion, and high speed flow. Applications of first and second law analysis to engineering systems.
Prerequisites: MENG 321 with a minimum grade of D

MENG 327. Mechatronics. (3 Credits)
This course introduces the principles of mechatronics, an interdisciplinary field that integrates mechanical, electrical, and computer engineering to design and create controlled systems. Students will learn how to apply sensors, actuators, microcontrollers, and programming to develop functional physical systems. Key topics include electronics fundamentals, measurement, sensors and actuators, and embedded systems.
Prerequisites: PHYS 122 with a minimum grade of D and MATH 260 (may be taken concurrently) with a minimum grade of D
Corequisites: MENG 327L

MENG 327L. Mechatronics Lab. (1 Credit)
This course introduces the principles of mechatronics, an interdisciplinary field that integrates mechanical, electrical, and computer engineering to design and create controlled systems. Students will learn how to apply sensors, actuators, microcontrollers, and programming to develop functional physical systems. Key topics include electronics fundamentals, measurement, sensors and actuators, and embedded systems.
Corequisites: MENG 327

MENG 330. Machine Design. (3 Credits)
Application of stress analysis and theories of failure to basic machine elements. Design of elements under static and fatigue loading. Design involving mechanical elements such as shafts, gears, springs, bearings, and fasteners.
Prerequisites: ENSC 301 with a minimum grade of D

MENG 341. Heat Transfer. (3 Credits)
One and multidimensional steady conduction, transient conduction, internal and external forced convection, natural convection, radiation heat transfer, boiling and condensation, heat exchangers.
Prerequisites: MENG 321 with a minimum grade of D and ENSC 352 with a minimum grade of D and MATH 260 with a minimum grade of D

MENG 362L. Thermal-Fluids Lab. (1 Credit)
This course provides hands-on experience with experiments related to thermodynamics, fluid mechanics, and heat transfer. Students will apply theoretical knowledge to practical problems, analyze experimental data, and develop technical communication skills through report writing. The course emphasizes teamwork, safety, and the application of engineering principles to thermal-fluid systems.
Prerequisites: MENG 321 with a minimum grade of D and ENSC 352 with a minimum grade of D
Corequisites: MENG 322, MENG 341

MENG 411. Instrumentation Systems. (3 Credits)
Basic concepts of measurement and analysis of measurement uncertainties and experimental data. Study of transducers and investigation of data acquisition, signal conditioning, and data processing hardware typically utilized in performing mechanical measurements.
Prerequisites: EENG 201 with a minimum grade of D and ENSC 371 with a minimum grade of D and MATH 321 with a minimum grade of D
Corequisites: MENG 411L

MENG 411L. Instrumentation Systems Lab. (1 Credit)
Laboratory exercises supporting the topics covered in MENG 411.
Corequisites: MENG 411

MENG 412. Mechanical Measurements. (3 Credits)
Study of the techniques used for measuring displacement, velocity, acceleration, force, pressure, flow, temperature, and strain. Investigation of the proper application and the associated limitations of the techniques and of the required instruments. The topics are studied within the context of obtaining experimental solutions to engineering problems in thermodynamics, heat transfer, fluid mechanics, mechanics, and strength of materials.
Prerequisites: MENG 411 with a minimum grade of D and MENG 341 with a minimum grade of D
Corequisites: MENG 412L

MENG 412L. Mechanical Measurements Lab. (1 Credit)
Laboratory exercises supporting the topics covered in MENG 412.
Corequisites: MENG 412

MENG 434. Vibration Engineering. (3 Credits)
Elements of vibrating systems. Free, forced harmonic and transient vibrations of single-degree-of-freedom systems with and without damping. Vibration isolation and control. Two-degree-of-freedom systems. Application of matrix techniques.
Prerequisites: ENSC 306 with a minimum grade of D and ENSC 371 with a minimum grade of D

MENG 435. Applications in Vibrations. (3 Credits)
Continuation of MENG 434. Practical applications of vibration theory to topics such as: Control and suppression of vibrations in machinery; vibration isolation and damping treatments; dynamic vibration absorbers; balancing of rotating and reciprocating machinery; critical speed evaluation of flexible rotors; ground vehicle response to road profile excitation and evaluation of ride performance; vibration in electronic equipment and prevention of vibration failures; aircraft vibration and flutter; and response of structures to earthquakes.
Prerequisites: MENG 434 with a minimum grade of D

MENG 442. Advanced Heat Transfer. (3 Credits)
Advanced heat transfer topics with emphasis on industry applications. Small length scale heat transfer problems, contact resistance, multidimensional transients, boiling and condensation heat transfer, and design of heat exchangers.
Prerequisites: MENG 341 with a minimum grade of D

MENG 443. Combustion. (3 Credits)
Combustion processes including explosions, detonations, flame propagation, ignition, and generation of pollutants in moving and stationary energy conversion systems. Focused on fundamental combustion theory in the context of internal combustion engines and, to a lesser degree, the subsequent effect of those emissions on the atmosphere, climate, and human health. Specific focus may vary from year to year.
Prerequisites: MENG 322 with a minimum grade of D or ENSC 355 with a minimum grade of D

MENG 445. Heating Vent and Air Condition. (3 Credits)
Introduction to the techniques used in the analysis and design of heating, ventilating, and air conditioning (HVAC) systems. Topics include the arrangement of typical air conditioning systems (i.e. all air systems, air and water systems, etc.), moist air processes, comfort and health criteria for indoor air quality, heating and cooling loads, piping system design, building air distribution, and operational principles and performance parameters of typical components (i.e., cooling towers, air washers, heating and cooling coils, etc.)
Prerequisites: MENG 341 with a minimum grade of D

MENG 446. Energy Auditing. (3 Credits)
This course provides a practical application of thermodynamics and heat transfer concepts with regard to commercial building systems (HVAC, lighting, automated controls, etc.). Students will learn how building systems use electric and natural gas energy, how to identify and make recommendations for how these systems can be made more efficient, and learn calculation methods to quantify these energy savings into useful metrics for clients.
Prerequisites: MENG 322 with a minimum grade of D and MENG 341 with a minimum grade of D

MENG 447. Advanced Energy Systems. (3 Credits)
This course is designed for students to understand the basic engineering principles of clean, renewable, and advanced energy conversion technologies. This course features an overview of various energy sources, their characteristics, and in-depth coverage of engineering technologies of converting these sources to electricity. Students should understand the engineering principles and limitations of each energy conversion technology. They will gain the ability to choose appropriate energy conversion techniques based on the application and energy resource availability.
Prerequisites: MENG 322 with a minimum grade of D and MENG 341 with a minimum grade of D

MENG 451. Computational Dynamics. (3 Credits)
A programming intensive course in applied numerical methods that will be explored using student-lead projects. Fundamental topics will include a variety of tools that arise in many types of problems, such as numerical linear algebra, multivariable root finding, and solving ordinary differential equations. Applications and projects may include simulation and prediction of system models, numerical solution of classical partial differential equations, studies in nonlinear dynamics, and optimization.
Prerequisites: ENSC 244 with a minimum grade of D and ENSC 371 with a minimum grade of D

MENG 456. Design for Manufacturing. (3 Credits)
Principles of Design for Manufacturing (DFM) are taught in the context of manufacturing engineering. Tool design, part features, tolerances and material processing parameters are discussed as examples to demonstrate how overall manufacturing costs are affected. Communication within the supply chain, upstream and downstream, are emphasized to achieve design and manufacturing costs goals. Traditional and nontraditional manufacturing (e.g. additive manufacturing) examples are used to show how DFM principles may be employed in globalized manufacturing. Recommendations from Bralla, Design for Manufacturing, are covered. Value engineering, outsourcing, reshoring, maquiladoras and other manufacturing trends are discussed.
Prerequisites: MENG 221 with a minimum grade of D

MENG 461. System Dynamics and Control. (3 Credits)
Principles of feedback control. Mathematical modeling and analysis of dynamic physical elements and systems. . Linearization to approximate dynamics with linear time-invariant models. Transient and steady-state response of first and second-order systems. Use of Laplace transforms. System response with zeros and additional poles. Transfer functions and block diagrams. Stability criteria and steady-state errors. Root locus and frequency response methods.
Prerequisites: ENSC 306 with a minimum grade of D and ENSC 371 with a minimum grade of D and (EENG 201 with a minimum grade of D or MENG 327 with a minimum grade of D)

MENG 465. Introduction to Finite Element. (3 Credits)
Development of the stiffness matrix method applied to bar and beam elements. The plane problem is discussed and plane elements are presented. The Isoperimetric formulation is introduced. Modeling and accuracy in linear analysis is considered. Utilizes a commercial finite element program in problem solving. One hour lecture and two hour computer Laboratory each week.
Prerequisites: ENSC 301 with a minimum grade of D

MENG 467. Design with Polymers and Composites. (3 Credits)
Background of composites, stress-strain relations for composite materials, extension and bending of symmetric laminates, failure analysis of fiber-reinforced materials, design examples and design studies, non-symmetric laminates, micromechanics of composites, properties of fibers and matrix materials.
Prerequisites: MENG 221 with a minimum grade of D

MENG 468. Biomaterials and Biomechanical Engineering. (3 Credits)
Introduction to the field of biomaterials and biomechanical engineering. Review and continuation of materials and mechanical properties concepts specific to biomaterials. Introduction to the disciplines of biomechanics and biomechanical engineering. Topics covered include orthopedic anatomy and function, implant technology, cardiac anatomy and function, and medical devices used to restore proper physiological function.
Prerequisites: MENG 221 with a minimum grade of D

MENG 477. Materials Selection for Design. (3 Credits)
Methods of materials selection. Systematic approaches for selecting optimal material when competing criteria exist. Real applications and case studies are included. Several topics including fracture mechanics, corrosion, titanium alloys, etc. are covered.
Prerequisites: MENG 221 with a minimum grade of D

MENG 478. Vehicle Dynamics. (3 Credits)
Overview of vehicle and engine construction. Various design conditions are covered including acceleration performance, braking forces, road loads, cornering, suspension modeling, and steering systems. Safety considerations for rollover. Tire modeling and its impact on system performance. The Vehicle Development Process is developed from concept through testing. The relationship between performance, emissions, safety, and fuel efficiency to the overall vehicle design is stressed. Each student will complete a project to propose a new vehicle market entry and establish the performance and related product technical specifications for this vehicle.
Prerequisites: ENSC 306 with a minimum grade of D
Enrollment limited to students with a semester level of Fourth Year (96+ credits) or Third Year (60-95.99 credits).

MENG 479. Tribology. (3 Credits)
In this course, you will learn about foundational concepts in surface metrology, contact mechanics, the nature of surfaces forces and fundamentals of friction, lubrication, war and failure, as well as properties of lubricant materials and bearing machine elements. Practical applications and case studies (for example, in automotive, aerospace and biotribology) will be discussed within the broader context of improving energy efficiency and reliability of mechanical systems through the application of these concepts.
Prerequisites: ENSC 301 with a minimum grade of D and (ENSC 352 with a minimum grade of D or ENSC 355 with a minimum grade of D)