Mechanical Engineering Courses (ME)

This is a list of all mechanical engineering courses. For more information, see Mechanical Engineering.

ME:0000 Mechanical Engineering Internship/Co-op 0 s.h.
Mechanical engineering students participating in the Cooperative Education Program register in this course during work assignment periods; registration provides a record of participation in the program on the student's permanent record. Requirements: admission to the Cooperative Education Program.

ME:1000 First-Year Seminar 0-1 s.h.
Small discussion class taught by a faculty member; topics chosen by instructor; may include outside activities (e.g., films, lectures, performances, readings, visits to research facilities). Requirements: first- or second-semester standing.

ME:2020 Mechanical Engineering Sophomore Seminar 0 s.h.
Introduction to the mechanical engineering profession and curriculum; ethics and professionalism in classroom and workplace; mentorship program and professional societies; visits to laboratories and local companies. Requirements: sophomore or transfer standing.

ME:2300 Fundamentals of Design and Manufacturing 3 s.h.
Fundamentals of design, engineering graphics, and manufacturing processing; computer graphics using Pro ENGINEER for CAD and CAM; typical industrial processes including casting, welding, machining, and forming; laboratory exercises and projects. Corequisites: ENGR:2720.

ME:3040 Thermodynamics II 3 s.h.
Power and refrigeration cycles; mixtures of gases, psychrometric mixtures; availability; thermodynamics of combustion and chemical equilibrium. Prerequisites: ENGR:2130.

ME:3045 Heat Transfer 3 s.h.

ME:3052 Mechanical Systems 4 s.h.
Topics in mechanical behavior and failure of materials; materials selection in design; stress and deflection analysis; static failure theories; fatigue and durability in design; fracture, statistical, and reliability considerations; introduction to finite element analysis using commercial software packages; standards, product liability, engineering ethics. Prerequisites: ENGR:2750. Corequisites: ENGR:2720 and ENGR:2760 and STAT:2020.

ME:3091 Professional Seminar: Mechanical Engineering 0 s.h.
Professional aspects of mechanical engineering: presentations, student/faculty interaction, professional society involvement, panel discussions, plant trip. Requirements: junior standing.

ME:3351 Engineering Instrumentation 2 s.h.
Basic elements of measuring circuits (bridges, voltage dividers, shunts, transformers); laboratory instrumentation (oscilloscopes, multimeters, power supplies, signal generators); amplifiers; frequency response principles; sensors; data acquisition, signal processing, filtering using Labview. Prerequisites: PHYS:1612 and ENGR:2120.

ME:4024 Mechanical Engineering Design and Parametric Modeling 3 s.h.
Design principles and methods to develop 3-D part models and assemblies; emphasis on use of mechanical engineering design principles and functional requirements through the complete design process using PTC Creo Parametric; for students with a basic knowledge of computer-aided design (CAD). Prerequisites: ENGR:2760. Corequisites: ENGR:2750 ME:3045.

ME:4048 Energy Systems Design 4 s.h.
Principles and design of energy conversion systems, including solar, wind, and geothermal power systems; design of thermal-fluid system components, modeling and simulation of systems, optimization techniques; design projects. Prerequisites: ME:3045 and ME:3040.

ME:4055 Mechanical Systems Design 3 s.h.
Kinematics of mechanisms, dynamics and vibration of machines, cam and gear, machine elements, computer-aided analysis of machines. Prerequisites: ENGR:2710 and ME:3052.

ME:4080 Experimental Engineering 4 s.h.

ME:4086 Mechanical Engineering Design Project 2-3 s.h.
Application of mechanical, thermal, fluid systems design; student or team design projects initiated at various levels in the design process and carried through to higher levels; emphasis on synthesis, written and oral communication. Corequisites: ME:4048 or ME:4055.

ME:4098 Individual Investigations: Mechanical Engineering arr.
Individual projects for mechanical engineering undergraduate students; laboratory study; engineering design project; analysis, synthesis, simulation of an engineering system; computer software development, research.

ME:4110 Computer-Aided Engineering 3 s.h.
Computational engineering modeling and simulation, geometric modeling, grid generation, finite-element and finite-volume methods, uncertainty analysis, optimization, engineering applications. Prerequisites: ME:3052 and ENGR:2750. Same as CEE:4515.

ME:4111 Numerical Calculations 3 s.h.
Development of algorithms for functional approximations, numerical differentiation and integration; solution of algebraic and differential equations, with emphasis on digital computations; initial and boundary value problems. Prerequisites: MATH:2560. Same as CEE:4511.

ME:4112 Engineering Design Optimization 3 s.h.
Engineering design projects involving modeling, formulation, and analysis using optimization concepts and principles; linear and nonlinear models, optimality conditions, numerical methods. Prerequisites: ENGR:2110 and MATH:2550. Requirements: junior standing. Same as CEE:4512.
ME:4113 Control of Mechanical Engineering Systems 3 s.h.
How to model simple engineering systems, apply time and frequency domain analysis techniques, and design control systems; application of these techniques using MATLAB; writing differential equations describing engineering systems and determine time domain response to a wide range of inputs; use of state-variable equations to model engineering systems and determine their time response to a wide range of inputs; describe advantages of feedback control; analyze performance of control systems; determine stability of control systems using Root-Locus, Bode, and Nyquist methods; design feedback control systems using frequency domain and state-variable methods. Prerequisites: MATH:2550 and MATH:2560 and ENGR:2710. Same as IE:4113.

ME:4115 Finite Element I 3 s.h.
One- and two-dimensional boundary value problems; heat flow, fluid flow, torsion of bars; trusses and frames; isoparametric mapping; higher order elements; elasticity problems; use of commercial software. Prerequisites: ENGR:2750. Same as CEE:4533, IGPI:4115.

ME:4116 Manufacturing Processes Simulations and Automation 3 s.h.
Material processing, metal cutting theories, forming, micro/nano fabrication, programmable logic controller, computer numerical controllers, discrete control system, DC and AC servo motors, Command generation. Prerequisites: ENGR:2760. Same as IE:4116.

ME:4120 State-Space Methods for Linear Control Systems arr.
Overview of system modelling and classical control design tools and methods, and bridges those with state-space approach for analysis and control of linear systems in the time domain; topics include linearization, root locus, Bode diagrams, Nyquist criteria, robustness margins, lead-lag compensators, observability and controllability, state-space realizations, internal stability and input-output stability, pole-placement, observers and reduced order observers, separation principle, performance limitations, linear quadratic regulator and its guaranteed margins, and optimal estimation. Prerequisites: MATH:2550 and MATH:2560 and ENGR:2710.

ME:4125 Biomimetic Fluid Dynamics 3 s.h.
Study and development of engineered systems that mimic the structure and function of biological systems; overview of the fluid dynamic principles that govern locomotion by swimming or flapping flight; equations of motion, fundamentals of aerodynamics; analytical models of force generation for swimming and flight; parameters governing effective locomotion; experimental and numerical studies to understand the present state of the art, challenges, and important questions. Prerequisites: ENGR:2510.

ME:4131 Manufacturing Systems 3 s.h.
Manufacturing and logistics systems, supply chain management, MRP/ERP systems, lean manufacturing, concurrent engineering, value stream mapping and six sigma. Offered spring semesters. Prerequisites: IE:3700 and ENGR:2760. Same as IE:3300.

ME:4142 Wind Turbine Aerodynamics 3 s.h.
Fluid mechanics of wind turbines and wind farms; engineering methodologies to design wind turbine blades; evaluation of rotor wakes; interaction between machines; effects of topography on wind turbine and wind farm performance. Prerequisites: ENGR:2510.

ME:4153 Fundamentals of Vibrations 3 s.h.
Vibration of linear discrete and continuous mechanical and structural systems; harmonic, periodic, and arbitrary excitation; modal analysis; applications. Prerequisites: ENGR:2750. Same as CEE:4532.

ME:4164 Fundamentals of Wind Turbines arr.
Application of fundamental principles of thermodynamics, fluid mechanics, and mechanical systems to wind turbine engineering; fundamentals of horizontal-axis wind turbines, wind energy conversion to useful work; wind turbine aerodynamics, performance, design of components; overview of wind resource and historical development of wind turbines; introduction to wind turbine installation and wind farm operation.

ME:4175 Computational Naval Hydrodynamics 3 s.h.
Simulations based on relevant vessels and propellers will be used to introduce the use of computational fluid dynamics for the analysis of surface and underwater marine craft performance, while also introducing naval hydrodynamics concepts related to resistance, propulsion, maneuvering, and seakeeping; an educational version of the naval hydrodynamics code REX will be freely distributed and used in the class. Prerequisites: ENGR:2510.

ME:4176 Experimental Naval Hydrodynamics 3 s.h.
Introduction to experimental methods for measurement of propeller thrust performance and resistance of surface vessels and underwater marine craft; present and expand on fundamental concepts related to fluid mechanics, measurement methods, and uncertainty analysis in a context that focuses on naval science and technology challenges; students work with models of relevant vessels and propellers in a dedicated towing tank facility. Prerequisites: ENGR:2510.

ME:4186 Enhanced Design Experience 2-3 s.h.
Experience working in teams on industry-sponsored design and product development projects scheduled for production; emphasis on practical experience with the complete design process, from conceptualization through prototyping, evaluation, testing, and production; written and oral communication. Prerequisites: ME:4086.

ME:4650 Mechatronics Engineering for Smart Device Design 3 s.h.
Introduction to basic mechatronics system components and design principles using mechatronics to meet functionality requirements of products, processes, and systems; lab-oriented assignments and team-based projects presented with innovative case studies in diverse application domains; labs require students to use a micro-controller kit to finish hardware development assignments; for students who plan to have a career in areas such as product development, robotics, design and manufacturing automation, technology management and innovations. Prerequisites: ENGR:2120 and ENGR:2760. Same as IE:4650.

ME:5113 Mathematical Methods in Engineering 3 s.h.
ME:5114 Nonlinear Control in Robotic Systems 3 s.h.
Nonlinear analysis and control systems theory; focus on
Lyapunov-based analysis methods and associated design
techniques; introduction to definitions of stability for
autonomous and nonautonomous systems leading to a
Lyapunov framework, and based on the developed Lyapunov-
based analysis tools, basic and advanced design tools for
contemporary engineering problems are presented, including
state-of-the-art techniques. Prerequisites: MATH:2560.

ME:5120 Vehicle System Dynamics 3 s.h.
Introduction to principles and basic procedures used in
analysis of vehicle system dynamics and design; topics
include tire mechanics, longitudinal and cornering tire force
characteristics, steady-state and transient vehicle cornering
responses, vehicle stability control, ride comfort, suspension
design, off-road vehicle mobility, tire-soil interaction, and
vehicle performance evaluations. Prerequisites: ME:2710.

ME:5143 Computational Fluid and Thermal Engineering 3 s.h.
Governing equations of fluid flow and heat transfer; basic
numerical techniques for solution of the governing equations;
estimation of accuracy and stability of the approximations;
boundary conditions; grid generation; applications to flows
and heat transfer in engineering systems; familiarity with
software for analysis and design of thermo-fluids systems.
Prerequisites: ME:3045.

ME:5145 Intermediate Heat Transfer 3 s.h.
Steady and unsteady conduction; forced and natural
convection; surface and gaseous radiation; condensation
and evaporation; analytical and numerical methods and
applications. Prerequisites: ME:3045.

ME:5146 Modeling of Materials Processing 3 s.h.
Manufacturing processes for metals, polymers,
semiconductors; processing by casting, solidification, crystal
growth, polymer molding and extrusion, welding, heat
treating, application of optical (laser) and electromagnetic
energy; processes that use momentum, heat, mass
transfer principles; measurement and instrumentation for
materials processing; current topics in materials processing.
Corequisites: ME:3045.

ME:5149 Propulsion Engineering 3 s.h.
Opportunity to develop basic understanding and knowledge
of rocket and airbreathing propulsion systems, relevant
terminology and analysis techniques, parameteric cycle
analysis for ideal engines, off-design analysis methods,
Requirements: graduate standing.

ME:5150 Intermediate Mechanics of Deformable Bodies 3 s.h.
Application of equilibrium analyses, strain-displacement
relations, and constitutive relationships to practical
structural systems and elementary plane elasticity problems.
Prerequisites: ENGR:2750. Same as BME:5660, CEE:5540.

ME:5154 Intermediate Kinematics and Dynamics 3 s.h.
Kinematic and dynamic analysis of mechanical systems;
computational kinematics, Lagrangian dynamics; principle
of virtual work in dynamics, constrained dynamics, spatial
dynamics. Prerequisites: ENGR:2710.

ME:5159 Fracture Mechanics 3 s.h.
3-D stress states, definition and criteria for failure, nominal
and local yield phenomena, linear elastic and elastic
plastic fracture mechanics, plane stress and plane strain
fracture toughness, J-Integral, crack opening displacement,
environmental assisted cracking, fatigue crack growth, fail
safe, and damage tolerant design. Prerequisites: BME:4910 or
ME:4055 or ME:5150. Same as CEE:5549.

ME:5160 Intermediate Mechanics of Fluids 3 s.h.
Basic concepts and definitions; pressure distribution in a
fluid; governing equations and boundary conditions; integral
and differential analysis; dimensional analysis and similarity;
experimental analysis; laminar and turbulent internal and
external flows; potential flows; engineering applications.
Prerequisites: ENGR:2510. Same as CEE:5369.

ME:5162 Experimental Methods in Fluid Mechanics and Heat Transfer 3 s.h.
Hands-on experience in methodology of conducting
experiments in fluid mechanics and heat transfer from design
to data acquisition and processing; essential theoretical
elements, experimental methodologies, data acquisition
systems, uncertainty analysis; wide variety of instruments
for fundamental and applied experimentation; work in small
groups; design, implement, test, and report an experiment in
area of interest. Same as CEE:5372.

ME:5167 Composite Materials 3 s.h.
Mechanical behavior of composite materials and their
engineering applications; composite constituents (fibers,
particles, matrices) and their properties and behavior;
macromechanical behavior of composite laminae;
micromechanical predictions of composite overall properties;
classical lamination theory; composite beams and plates.
Prerequisites: ENGR:2750. Same as CEE:5137.

ME:5179 Continuum Mechanics arr.
Mechanics of continuous media; kinematics of deformation,
concepts of stress and strain; conservation laws of mass,
momentum and energy; constitutive theories; boundary
and initial value problems. Prerequisites: ENGR:2750 or
ENGR:2510. Same as CEE:5179.

ME:5195 Contemporary Topics in Mechanical Engineering arr.
New topics in fluid and thermal sciences and mechanical
systems not covered in other courses; topic and coverage
determined by student/faculty interest. Requirements:
junior standing.

ME:5210 Intermediate Thermodynamics 3 s.h.
Fundamental principles of thermodynamics as applied to
phase equilibrium; properties of fluids, first and second
law, variable composition systems, behavior of real fluids,
mathematical techniques for solution thermodynamics.
Requirements: CBE:3105 or ME:3040 or graduate standing.
Same as CBE:5110.

ME:5236 Optimization of Structural Systems 3 s.h.
Advanced topics; optimization of structural topology,
shape, and material; finite dimensional dynamic response
optimization, sensitivity analysis, distributed parameter
systems; projects. Same as BME:5720, CEE:5236.

ME:5360 Control Theory 3 s.h.
State space approach; controllability, observability, canonical
forms, Luenberger observers, feedback control via pole
placement, stability, minimal realization and optimal control.
Prerequisites: ECE:3600. Same as ECE:5600.
ME:5362 Computer-Based Control Systems 3 s.h.
Discrete and digital control systems; application of computers in control; sampling theorem; discrete time system models; analysis and design of discrete time systems; control design by state variable and input/output methods; advanced topics in digital controls; lab. Prerequisites: ECE:5600. Same as ECE:5640, IGPI:5641.

ME:6191 Graduate Seminar: Mechanical Engineering 1 s.h.
Presentation and discussion of recent advances and research in mechanical engineering by guest lecturers, faculty, students.

ME:6198 Individual Investigations: Mechanical Engineering arr.
Individual project in mechanical engineering, for department graduate students; laboratory study, engineering design project, analysis and simulation of an engineering system, computer software development, research.

Experimental and/or analytical investigation of an approved topic for partial fulfillment of requirements for M.S. with thesis in mechanical engineering.

ME:6214 Analytical Methods in Mechanical Systems 3 s.h.
Vector and function spaces; functionals and operators in Hilbert spaces; calculus of variations and functional analysis with application to mechanics; Ritz and Galerkin methods. Prerequisites: ME:5113. Same as CEE:6310.

ME:6215 Finite Element II 3 s.h.
Computer implementation; plate and shell elements; mixed and hybrid formulations; nonlinear analysis; recent development; introduction to boundary element method. Prerequisites: CEE:4533. Same as CEE:6532, IGPI:6216.

ME:6216 Laser Materials Processing 3 s.h.
Proficient engineering background involved in laser processing and manufacturing; fundamentals and operation principles for various types of laser systems; laser optics, principles of laser-matter interactions, laser-induced thermal and thermo-mechanical effects; emerging areas of laser applications (e.g., microscale and nanoscale laser processing, ultrafast laser processing) and related energy transport analyses; video demonstrations. Prerequisites: ME:3045 and MATH:3550.

ME:6217 Advanced Modeling and Simulation for Manufacturing 3 s.h.
How materials often behave in a complicated manner involving deeply coupled effects among stress/stain, temperature, and microstructure during a manufacturing process; modeling and prediction of material processes based on a metallo-thermomechanical coupled analysis; focus on heat transfer modeling in material processes, fundamental mechanics aspects required for material processing analysis, and microstructural evolution modeling in material processes. Prerequisites: CEE:4533 and ME:3045.

ME:6245 Diffusive Transport 3 s.h.
Diffusive transport of heat, mass, and momentum; phenomenological laws and analogies; analytical and numerical solution techniques; inverse heat conduction; multiphase and multicomponent systems. Prerequisites: ME:5145. Same as CBE:6145.

ME:6246 Advanced Numerical Methods for Mechanical Systems 3 s.h.
Introduction to meshfree particle methods, extended finite element method, material stability analysis, thermal-mechanical coupling, and coupling of finite element/meshfree methods. Requirements: ME:4115 or ME:5143 or background in computational mechanics, computational chemistry, or computational physics.

ME:6247 Contact Mechanics 3 s.h.
Varied aspects of contact mechanics and engineering applications, including stationary contacts, sliding, rolling, impact, and fretting fatigue; emphasis on theoretical basis of solutions of contact mechanics problems; mathematical methods of solving contact problems using Green's function method; complex potentials and integral transform methods. Prerequisites: ME:5113 and ME:5150.

ME:6255 Multiscale Modeling 3 s.h.
Computational modeling of engineering materials ranging from molecular to continuum scales, molecular dynamics and Monte Carlo methods, nanoscale continuum modeling, scale-coupling methods. Prerequisites: ME:5143 or CEE:4533. Same as CEE:7549.

ME:6258 Computational Ship Hydrodynamics 3 s.h.
Introduction to computation of problems in three main areas of ship hydrodynamics: resistance and propulsion, seakeeping, and maneuvering; focus on issues of simulating operating ships, modeling methods, and numerical techniques used to approach ship hydrodynamics. Prerequisites: ME:5160. Corequisites: ME:5143.

ME:6260 Viscous Flow 3 s.h.
Equations of viscous flow; classical analytical and numerical solutions; flow regimes and approximations; laminar boundary layers—equations, solution methods, applications; stability theory and transition; incompressible turbulent flow—mean-flow and Reynolds-stress equations, modeling, turbulent boundary layers and free shear flows. Requirements: for ME:6260—ME:5160; for CEE:6376—CEE:5369. Same as CEE:6376.

ME:6261 Multibody System Dynamics 3 s.h.
Introduction to principles of analytical and computational dynamics for rigid and flexible multibody systems; spatial kinematics and dynamics of rigid body systems, numerical solution procedures for multibody dynamics analysis, and flexible multibody dynamics. Prerequisites: ME:5154.

ME:6262 Inviscid Flow 3 s.h.
Derivation of governing equations for fluid flow; general theorems for motion of inviscid, incompressible flows; solution techniques for two- and three-dimensional irrotational flows; forces and moments acting on immersed bodies; vortex kinematics and dynamics; steady and unsteady aerodynamic theory. Prerequisites: ME:5160.

ME:6263 Compressible Flow arr.
Compressible flow behavior; 1-D unsteady flow and appropriate use of x-t diagrams; 2-D flows and use of the method of characteristics; Burgers' Equation and its properties.

ME:6275 Advanced Heat Transfer 3 s.h.
Conservation laws, forced and natural convection; surface and gaseous radiation; analytical and numerical methods; applications. Prerequisites: ME:5145.
ME:6278 Nonlinear Elasticity 3 s.h.
Nonlinear elasticity theory; modern applications in biomechanics; vectors and tensors, constitutive theory of elastic material, some exact solutions of boundary value problems, inverse deformation relations, stability of elastic material, theories of tissue adaptive response. Prerequisites: ME:5150. Requirements: elementary linear elasticity.

ME:6534 Applied Optimal Design 3 s.h.
Optimal design problem formulation; optimality conditions; linear, quadratic, convex, and nonlinear programming; Lagrangian duality; numerical algorithms for unconstrained and constrained design problems, design sensitivity analysis, engineering applications. Prerequisites: CEE:5513. Same as CEE:6534.

ME:6810 Advanced Topics on Additive Manufacturing 3 s.h.
Review of critical challenges facing 3-D printing; emphasis on techniques and practical experience in developing novel additive manufacturing processes and applications; topics include 3-D content creation and preparation, CAD systems for additive manufacturing, additive manufacturing processes, fabrication speed and improvements, rapid tooling and indirect processes. Same as IE:6810.

ME:7248 Combustion Theory 3 s.h.
Laminar flame theory; turbulent combustion; spray combustion; thermal ignition; pollutant formation, oxidation; combustion diagnostics. Prerequisites: ME:5145 and ME:5160.

ME:7250 Advanced Fracture Mechanics 3 s.h.
Fracture of modern engineering materials; linear-elastic fracture; computational methods; functionally graded materials; elastic-plastic fracture; multiscale fracture and fatigue crack initiation. Prerequisites: ME:5113 and (ME:5159 or CEE:4533). Same as CEE:7250.

ME:7256 Computational Solid Mechanics 3 s.h.
Advanced computational methods for nonlinear and dynamic analysis of solids, structures; new space- and time-discretization methods for problems, including highly nonlinearities, large deformation, contact/impact conditions. Prerequisites: ME:5113 and CEE:4533.

ME:7257 Probabilistic Mechanics and Reliability 3 s.h.
Stochastic and reliability analysis of mechanical systems; computational methods for structural reliability; random eigenvalue problem; random field and stochastic finite element methods. Prerequisites: CEE:4533 and ME:5113.

ME:7259 Mechanical Design in Structures 3 s.h.
Discrete and continuum variational equilibrium equations, discrete design sensitivity analysis for static responses and eigenvalues, interactive design workstation, continuum sizing design sensitivity analysis for static responses and eigenvalues, design sensitivity analysis of structural dynamics, differentiability theory, shape optimal design, shape design sensitivity analysis, design sensitivity of nonlinear structural systems. Prerequisites: CEE:4533 and ME:5113 and ME:5150.

ME:7266 Interfacial Flows and Transport Processes 3 s.h.
Physics of fluid interfaces and numerical techniques to simulate interface dynamics; interfacial flow coupled with thermal-fluid transport, from molecular interactions to continuum approximations; development of computer code segments to track and represent interface-flow interactions. Prerequisites: ME:5145 and ME:5160.

ME:7267 Multiphase Flow and Transport 3 s.h.
Thermodynamic and mechanical aspects of interfacial phenomena and phase transitions; nucleation, phase-change, species transport, particulate flows, liquid-vapor systems, solidification, porous media. Prerequisites: ME:5145 and ME:5160.

ME:7268 Turbulent Flows 3 s.h.
Origin; need for modeling, averages, Reynolds equations, statistical description; experimental methods and analysis; turbulence modeling; free shear layers and boundary layers; complex shearflows; development of computational strategies; recent literature on theory and applications, chaos phenomena. Prerequisites: ME:5160.

ME:7269 Computational Fluid Dynamics and Heat Transfer 3 s.h.
Development of numerical and algebraic approximations for elliptic, parabolic, hyperbolic partial differential equations; finite-volume, spectral, pseudo-spectral, Galerkin techniques; stability of numerical methods; CFL condition; stiff problems; adaptive grid generation and boundary-fitted coordinates; numerical solutions for one- and two-dimensional compressible and incompressible fluid flow and heat transfer problems. Prerequisites: ME:4111 and ME:5160.

ME:7295 Advanced Topics in Mechanical Systems 3 s.h.
Advanced contemporary topics in mechanical systems engineering not covered in other courses and determined by student/faculty interest.

Experimental and/or analytical investigation of an approved topic for partial fulfillment of requirements for Ph.D. in mechanical engineering.