Mechanical Engineering

Chair
- Ching-Long Lin

Undergraduate major: mechanical engineering (B.S.E.)
Graduate degrees: M.S. in mechanical engineering; Ph.D. in mechanical engineering
Faculty: https://me.engineering.uiowa.edu/people
Website: https://me.engineering.uiowa.edu

Courses

Mechanical Engineering Courses

ME:0000 Mechanical Engineering Internship/Co-op 0-1 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:2200 Introduction to Mechanical Engineering Design 2 s.h.
Solid modeling, assemblies, drawings, and Geometric Dimensioning and Tolerancing (GD&T); basic engineering design process; introduction to engineering standards, product liability, and ethics. Prerequisites: ENGR:1100.

ME:2300 Manufacturing Processes 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 and (ME2200 or BME:2710).

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

ME:3045 Heat Transfer 3 s.h.
Principles of heat transfer by conduction, convection, radiation; analytical and numerical methods of solution; applications to engineering problems. Prerequisites: MATH:3550 and ENGR:2510 and ENGR:1300.

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 ME:2300 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:3600 Control of Mechanical Engineering Systems 3 s.h.
Introduction to fundamental control theory and robot manipulators. Prerequisites: MATH:2560 and ENGR:2710.

ME:4024 Product Design and Realization 3 s.h.
Design principles and methods to develop 3D 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 or ME:2200. Corequisites: ENGR:2750.

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.

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 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.

ME:4111 Scientific Computing and Machine Learning 3 s.h.
Numerical methods in scientific computing; root problems and optimization; linear algebraic equations; eigenvalue problems; numerical differentiation and integration; interpolation and curve-fitting; initial value and boundary value problems; machine learning in regression, classification, and clustering problems; Python programming and packages. 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 CEE:4513.

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: ME:2300. Same as ISE:4113.

ME:4117 Finite Element Analysis 3 s.h.
Trusses and frames; Rayleigh-Ritz methods; 2D and 3D elasticity problems; heat transfer, thermo-mechanical coupling; transient problems; use of commercial software for applications in analysis and design of mechanical engineering systems. Prerequisites: ENGR:2750.

ME:4120 Advanced Linear Control Systems 3 s.h.
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: ME:3600 or (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:4140 Modern Robotics and Automation 3 s.h.
Introduction to basics of robotics and automation; mechanical design development and manufacturing of smart and automated devices, components, and systems; principles of robotic motion and kinematics; introduction to process automation through system requirement identification, equipment integration, sensors, actuation, and logical control; fundamentals of design, analysis, and manufacturing to meet functionality requirements of products, devices, and systems using the principles of mechatronics to develop smart and automated products. Prerequisites: ENGR:2710.

ME:4145 Industrial Internet of Things (IIoT) 3 s.h.
Introduction to process automation through system requirement identification, equipment integration, sensors, actuation, and logical control; fundamentals of design, analysis, and manufacturing to meet functionality requirements of products, devices, and systems using principles of mechatronics to develop smart and automated products; integration of advanced networking and monitoring into device control and automation. Corequisites: ME:3351.

ME:4150 Artificial Intelligence in Engineering 3 s.h.
Artificial intelligence, computational intelligence, data science and engineering, machine intelligence, digital manufacturing and design, intelligent machining, fault diagnosis, autonomy, robotics; applications in mechanical engineering. Prerequisites: ME:4111.

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:4160 Engines and Power Plants 3 s.h.
Fundamental principles of thermodynamics applied to areas of particular interest in mechanical engineering; power plants and refrigeration cycles, internal combustion engine cycles, gas mixtures and combustion, mixing processes and pollutant formation, and hybrid power systems. Prerequisites: ENGR:2130.

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:4200 Modern Engineering Materials for Mechanical Design 3 s.h.
Overview of design approaches for different engineering materials (i.e., metals, polymers, ceramics); topics include manufacturing processes, smart and advanced functionalities for applications in emerging engineering fields, theoretical models describing mechanical behavior, failure mechanisms, and design criteria; introduction to composite materials; computer lab activities focus on finite element method (FEM) simulations of materials with different mechanical properties. Prerequisites: ME:3052.

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: ME:3600 or ME:4120 or CBE:4105 or ECE:3600.

ME:5115 Cooperative Autonomous Systems 3 s.h.
How to enable ground, marine, and aerial robotic platforms to perform cooperative tasks autonomously in complex real-world environments; theoretical topics include numerical approximation, optimal control, nonlinear analysis and control, game theory, and graph theory; project-based activities in a laboratory environment; focus on design and implementation of motion planning, tracking, collision avoidance, and cooperative control algorithms for autonomous vehicles. Prerequisites: ME:3600 or ME:4120 or ME:4113 or CBE:4105 or ECE:3600.

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: ENGR: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, parametric cycle analysis for ideal engines, off-design analysis methods, problem-solving methodology. Prerequisites: ENGR:2130. 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 plate elasticity problems. Prerequisites: ENGR:2750. Same as 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.
Three-dimensional 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: ENGR:2750. Corequisites: ME:3052. 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.
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<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>ME:5162</td>
<td>Experimental Methods in Fluid Mechanics and Heat Transfer</td>
<td>3 s.h.</td>
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<tr>
<td>ME:5167</td>
<td>Composite Materials</td>
<td>3 s.h.</td>
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<tr>
<td>ME:5179</td>
<td>Continuum Mechanics</td>
<td>arr.</td>
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<td>ME:5195</td>
<td>Contemporary Topics in Mechanical Engineering</td>
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<td>ME:5210</td>
<td>Intermediate Thermodynamics</td>
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<tr>
<td>ME:6191</td>
<td>Graduate Seminar: Mechanical Engineering</td>
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<tr>
<td>ME:6198</td>
<td>Individual Investigations: Mechanical Engineering</td>
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<td>ME:6214</td>
<td>Analytical Methods in Mechanical Systems</td>
<td>3 s.h.</td>
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<tr>
<td>ME:6215</td>
<td>Finite Element II</td>
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<td>ME:6216</td>
<td>Laser Materials Processing</td>
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<td>ME:6217</td>
<td>Advanced Modeling and Simulation for Manufacturing</td>
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<td>ME:6240</td>
<td>Probabilistic Inference and Estimation for Mechanical Systems</td>
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<td>ME:6245</td>
<td>Diffusive Transport</td>
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<td>ME:6247</td>
<td>Contact Mechanics</td>
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<td>ME:6255</td>
<td>Multiscale Modeling</td>
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<td>ME:6260</td>
<td>Viscous Flow</td>
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<tr>
<td>ME:6261</td>
<td>Multibody System Dynamics</td>
<td>3 s.h.</td>
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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 3 s.h. (arr.)
Compressible flow behavior; 1D unsteady flow and appropriate use of x-t diagrams; 2D 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:6300 Control of Networked Autonomous Systems 3 s.h.
Introduction to state-of-the-art research in networked autonomous robotic systems; graph theory based network models, decentralized control, multi-agent cooperation, and mobile sensor networks. Corequisites: ME:5115 or ME:5114.

ME:6320 Fluid-Structure Interactions 3 s.h.
Foundations of fluid-structure interactions (FSI) with focus on hydro-electric responses of flexible structures in dense fluids; structural dynamics and fluid dynamics are too often characterized as distinct disciples and this dichotomous mindset fails to recognize the important effects that dynamics fluid loads exert upon structural vibrations and vice-versa; students are equipped with knowledge to approach modern FSI problems; foundations of theoretical FSI, experimental methods, and computational approaches. Prerequisites: (ME:5160 or ME:4125) and (ME:4153 or ME:5154).

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: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.

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