

# MECHANICAL ENGINEERING

The graduate program in the Department of Mechanical Engineering expands students' understanding of the fundamentals of mechanical engineering while introducing them to modern technologies and equipping them with in-depth knowledge of their specialty area. Faculty have strong research programs in dynamics, vibrations and controls, fluid mechanics, heat transfer and energy systems, materials and manufacturing, solid mechanics, and systems engineering.

Visit the Department of Mechanical Engineering website (<https://www.uakron.edu/engineering/me/>) to learn more about its faculty and facilities.

- Manufacturing, Certificate (<https://bulletin.uakron.edu/graduate/colleges-programs/engineering/mechanical-engineering/manufacturing-certificate/>)
- Mechanical Engineering, MS (<https://bulletin.uakron.edu/graduate/colleges-programs/engineering/mechanical-engineering/mechanical-engineering-ms/>)

## Mechanical Engineering (MECE)

### MECE 500 Thermal System Components (3 Units)

Performance analysis and design of basic components of thermal energy exchange and conversion systems. Components studied include heat exchangers, pumps, compressors, turbines and expansion engines. (Formerly 4600:500)

### MECE 510 Heating & Air Conditioning (3 Units)

Prerequisite: Permission. Thermodynamics of gas mixtures. Design and selection of air conditioning equipment. Control of gas mixtures, heating, cooling, and humidity. (Formerly 4600:510)

### MECE 511 Compressible Fluid Mechanics (3 Units)

Subsonic and supersonic flow in nozzles, diffusers, and ducts. One-dimensional reactive gas dynamics. Prandtl-Myer theory. Applications to design and analysis of compressors, turbines, and propulsion devices. (Formerly 4600:511)

### MECE 512 Aircraft Flight Mechanics (3 Units)

Introduction to basic aerodynamics, airplane performance, stability and control, astronautics and propulsion. Design considerations are emphasized. (Formerly 4600:512)

### MECE 513 Introduction to Aerodynamics (3 Units)

Introduction of aerodynamic concepts; conformal transformations, theory of thin airfoils, 2-dimensional airfoil theory, wings of finite span, lifting line theories, lumped-vortex, vortex-lattice, and panel methods. (Formerly 4600:513)

### MECE 514 Introduction to Aerospace Propulsion (3 Units)

Introduction to propulsion systems currently used in aerospace fields; propulsion principles for turbojets, chemical rockets, and electrical rocket propulsion. (Formerly 4600:514)

### MECE 515 Energy Conversion (3 Units)

Prerequisite: Permission. Topics from fields of internal combustion engines, cycle analysis, modern conversion devices. (Formerly 4600:515)

### MECE 516 Heat Transfer Processes (3 Units)

Prerequisite: Permission. Analysis, design of extended surfaces. Natural convection and mixed convection, combined modes of heat transfer with phase changes. (Formerly 4600:516)

### MECE 522 Experimental Stress Analysis I (3 Units)

Prerequisite: Permission. Experimental methods of determining stress or strain: brittle lacquer, strain gages, photoelasticity, full field thermal techniques. (Formerly 4600:522)

### MECE 530 Machine Dynamics (3 Units)

Prerequisite: Permission. Static and dynamic forces in machines, products of inertia, dynamic equivalence, flywheels. Balancing of rotating, reciprocating, cyclic plane motion. Computer simulation of transient mechanism dynamics, other topics in advance dynamics. (Formerly 4600:530)

### MECE 531 Fundamentals of Mechanical Vibrations (3 Units)

Prerequisite: Permission. Undamped and forced vibrations of systems having one or two degrees of freedom. (Formerly 4600:531)

### MECE 532 Vehicle Dynamics (3 Units)

Prerequisite: Permission. Application of dynamic systems analysis techniques to road vehicles. Newtonian and Lagrangian methods. Tire/road interface. Ride characteristics, handling and stability. Digital simulation. (Formerly 4600:532)

### MECE 540 System Dynamics & Control (4 Units)

Prerequisite: Permission. Laplace transforms. Mathematical models of physical systems. Transient response and stability. Error analysis and system accuracy. Root locus methods in design. Frequency analysis and design. Compensation techniques. (Formerly 4600:540)

### MECE 541 Control Systems Design (3 Units)

Prerequisite: Permission. Methods of feedback control design such as minimized error, root-locus, frequency domain. Compensation techniques. Multivariable and nonlinear design methods and computer-aided control design. (Formerly 4600:541)

### MECE 542 Industrial Automatic Control (3 Units)

Prerequisite: Permission. Operation of basic control mechanisms. Study of mechanical, hydraulic, pneumatic, fluidic control systems, including application areas. Tuning of control devices for optimum performance of system. Case studies on control applications from industry, e.g. boilers, furnaces, process heaters. (Formerly 4600:542)

### MECE 543 Optimization Methods in Mechanical Engineering (3 Units)

Prerequisite: Permission. Development and method of solution of optimization problems in mechanical engineering. The use of dynamic programming and operational research methods for optimization including computer utilization and applications. (Formerly 4600:543)

### MECE 544 Robot Design, Control & Application (3 Units)

Prerequisite: Permission. Robot design and control. Kinematic transformations, velocities and accelerations, path trajectories and dynamics, control and sensing in robotics. The automated factory with robot applications. (Formerly 4600:544)

### MECE 550 Introduction to Computational Fluid Flow & Convection (3 Units)

Prerequisite: Permission. Numerical modeling of fluid/thermal systems, numerical solution of the momentum and thermal boundary layer equations; flow simulation using advanced heat transfer/fluid/graphics packages. (Formerly 4600:550)

### MECE 562 Pressure Vessel Design (3 Units)

Prerequisite: Permission. Introduction to modern pressure vessel technology. Topics include basic structural considerations, materials and their environment and design-construction features. (Formerly 4600:562)

**MECE 563 Computer Aided Design & Manufacturing (3 Units)**

Prerequisite: Permission. The use of computer systems to assist in the creation, modification, analysis, or optimization of engineering designs, and to plan, manage, and control manufacturing plants. (Formerly 4600:563)

**MECE 585 3D Printing and Additive Manufacturing (3 Units)**

Understanding principles and theories in additive manufacturing processes; Understanding process models, materials, design for additive manufacturing (DfAM), and applications; Hands-on practice and research project; State of the art of additive manufacturing. (Formerly 4600:585)

**MECE 600 Gas Dynamics (3 Units)**

Prerequisite: MECE 511. Derivation of equations for multi-dimensional irrotational flow of a compressible fluid. Method of small perturbations. Method of characteristics. Ideal flow theory. Transonic flow. One dimensional unsteady flow. (Formerly 4600:600)

**MECE 608 Advanced Thermodynamics (3 Units)**

Extension and generalization of basic laws of thermodynamics with application to a variety of physical and biological systems. Introduction to irreversible thermodynamics, the third law and statistical thermodynamics. (Formerly 4600:608)

**MECE 609 Finite Element Analysis I (3 Units)**

Prerequisite: MECE 622. Introductory development of finite element method as applied to various topics from continuum mechanics. Areas covered include plane; axisymmetric and 3-D stress analysis; conduction; fluid mechanics; transient problems and geometric and material nonlinearity. (Formerly 4600:609)

**MECE 610 Dynamics of Viscous Flow I (3 Units)**

Derivation and solution of equations governing laminar viscous flow. Applications include unsteady flows, slow viscous flows, parallel flows, lubrication theory and laminar boundary layers. (Formerly 4600:610)

**MECE 611 Computational Fluid Dynamics I (3 Units)**

Prerequisite: MECE 610 or permission of instructor. Study of numerical methods in fluids; numerical errors and stability, finite differencing, nonlinear convection terms, Poisson equations, boundary conditions, turbulence, spectral and finite element techniques. (Formerly 4600:611)

**MECE 615 Conduction Heat Transfer (3 Units)**

Study of one-, two- and three-dimensional heat conduction. Development of analytical techniques for analysis and design. (Formerly 4600:615)

**MECE 616 Convection Heat Transfer (3 Units)**

Heat transfer from laminar, turbulent external, internal flows. Convective heat transfer at high velocities. Heat transfer to liquid metals; high Prandtl number fluids. (Formerly 4600:616)

**MECE 617 Radiation Heat Transfer (3 Units)**

Study of governing radiation laws. Black and real systems, geometric factors, gray enclosures, non-gray systems, gaseous radiation, radiation equipment. (Formerly 4600:617)

**MECE 618 Boiling Heat Transfer & Two-Phase Flow (3 Units)**

Current techniques to determine heat transfer and pressure drop in components such as boilers, heat exchangers, and steam generators, with boiling. Boiling mechanism, slip ratio, critical heat flux and instabilities in boiling flow systems. (Formerly 4600:618)

**MECE 620 Experimental Stress Analysis II (2 Units)**

Prerequisite: MECE 522. Dynamic strain gage methods, transducer design, Moire fringe techniques and topics in photoelasticity. (Formerly 4600:620)

**MECE 621 Introduction to Tire Mechanics (3 Units)**

Prerequisite: Permission. Topics include tire as vehicle component, tire traction and wear, laminated structures, tire stress and strains and advanced tire models. (Formerly 4600:621)

**MECE 622 Continuum Mechanics (3 Units)**

Prerequisite: Permission. Analysis of stress and deformation at a point. Derivation of fundamental field equations of fluid and solid mechanics by applying basic laws of dynamics, conservation of mass and energy. Development of constitutive laws. (Formerly 4600:622)

**MECE 623 Applied Stress Analysis I (3 Units)**

Applications of applied elasticity, energy principles and variational methods to determine stresses in structures. (Formerly 4600:623)

**MECE 624 Fundamental of Fracture Mechanics (3 Units)**

Prerequisite: MECE 622 or permission of instructor. Methods of stress analysis in elastic media containing holes and cracks. Theories of brittle fracture. Dynamic crack propagation. Fatigue fractures. Finite element approaches to fracture mechanics. (Formerly 4600:624)

**MECE 625 Analysis of Mechanical Components (3 Units)**

Theories of failure and plastic flow. Fatigue, creep analysis and introduction to fracture mechanics. (Formerly 4600:625)

**MECE 626 Fatigue of Engineering Materials (3 Units)**

Prerequisite: MECE 624 or permission. Quasi-static and cyclic behavior; dislocation networks and their interactions; correlation of dislocation-microstructure interactions; crack initiation; crack propagation; short cracks; crack closure; environmental effects. (Formerly 4600:626)

**MECE 627 Advanced Materials & Manufacturing Processes (3 Units)**

Manufacturing processes for advanced materials; classification; technological aspects of bulk deformation, casting, joining, forming, machining, molding, powder metallurgy, rapid solidification; economic aspects; technical activity. (Formerly 4600:627)

**MECE 628 Mechanical Behavior of Materials (3 Units)**

Prerequisite: Permission. Mechanical behavior of engineering materials; metallurgy of deformation; dislocation effects and deformation; strengthening mechanisms; thermomechanical processing; mechanical testing. (Formerly 4600:628)

**MECE 629 Nonlinear Engineering Problems (3 Units)**

Prerequisite: MECE 622. Study of nonlinear ordinary and partial differential equations governing phenomena of mechanics. Analysis of phase space trajectories, singularities and stability. Development of approximate analytical methods. (Formerly 4600:629)

**MECE 630 Vibrations of Discrete Systems (3 Units)**

Study of vibrations of multidegree of freedom systems including free and forced vibrations, damped and transient response, normal mode vibrations and matrix iteration techniques. Application to seismic design and shock design. (Formerly 4600:630)

**MECE 631 Kinematic Design (3 Units)**

Prerequisite: Permission of instructor. The geometry of constrained motion. Analysis of relative plane motion using vectors and the digital computer. Curvature theory. Synthesis of linkages and gearing. Introduction to computer-aided design. (Formerly 4600:631)

**MECE 632 Reliability in Design (3 Units)**

Prerequisite: STAT 561. The reliability determination of mechanical components and systems and its use in design. Distribution, reliability determination, normal and log-normal theories, Weibull theory, life spectrum analysis, renewal theory and confidence limits. (Formerly 4600:632)

**MECE 633 Computerized Modal Analysis of Structures (3 Units)**

Prerequisite: MECE 630 or equivalent. Modal analysis theory and measurement techniques, digital signal processing concepts, structural dynamics theory, modal parameter estimation with 'hands-on' experience in the application of modal measurement methods in vibration analysis. (Formerly 4600:633)

**MECE 634 Advanced Dynamics of Rotating Machinery (3 Units)**

Prerequisite: MECE 530 or equivalent. Dynamic modeling and simulation of complex rotor-bearing systems. Steady state, transient and stability analysis with inertia, gyroscopic, imbalance, rotor-bow, disk-skew and impeller-rub interaction effects. (Formerly 4600:634)

**MECE 635 Stress Waves in Solids (3 Units)**

Propagation of waves through solids and fluids. Dispersion, transmission, reflection, absorption and diffraction phenomena. Shock loading, low and high velocity impact. (Formerly 4600:635)

**MECE 642 System Analysis & Control Design (3 Units)**

Uniform methods of modeling and response analysis, controllability and observability, stability theory and analysis of linear and nonlinear engineering processes. Design of feedback controls for optimum performance for multivariable real-time control application. (Formerly 4600:642)

**MECE 645 Process Identification & Computer Control (3 Units)**

Prerequisite: Permission. Obtaining mathematical models of processing from noisy observations. Methods of digital control design. Case studies on computer control of selected processes. (Formerly 4600:645)

**MECE 646 Expert Systems in Controls & Manufacturing (3 Units)**

Prerequisite: MECE 540 or equivalent or by permission. Expert system methodologies for process control, computer integrated flexible manufacturing and robotics. (Formerly 4600:646)

**MECE 647 Neural & Fuzzy Control Systems (3 Units)**

Prerequisite: MECE 540 or permission of instructor. Analysis and design of intelligent control systems. Neural networks and fuzzy sets for process identification and controller design. Applications and case studies in industry. (Formerly 4600:647)

**MECE 650 Tribology (3 Units)**

Fundamentals of friction lubrication and wear are treated; includes origins of friction and wear, material properties and contacting surfaces, lubricants and their function, and engineering approaches to mitigate friction and wear. Specific topics include adhesive and abrasive friction/wear, boundary lubrication, fluid film bearings and their lubrication, rolling element bearings, bearing modeling, materials and engineering, and forensic analyses of tribological elements. (Formerly 4600:650)

**MECE 655 Micro- and Nano-Fluid Dynamics (3 Units)**

Prerequisite: MECE 611 or permission of instructor. The course includes fundamentals of the analytical and numerical solutions of the problems pertinent to fluid mechanics on nano- and micro- scales. Applications will include micro-engines, MEMS, micro-filters, and synthesis of nano-materials. (Formerly 4600:655)

**MECE 658 Mechanical Behavior of Nanostructured Materials & Composites (3 Units)**

The course is open to students in mechanical engineering, polymer science and polymer engineering, biology and all other engineering disciplines. Some prior consultation with the instructor is encouraged. The course is considered as a graduate elective in ME. An Overview of Lattice Dislocation Theory, Nanostructured Materials: Processing and Properties, Grain Boundaries, Nanoindentation, Electron Microscopy, Atomic Force Microscopy, Carbon Nanotubes, Polymer and Bio-MEMS. (Formerly 4600:658)

**MECE 660 Engineering Analysis (3 Units)**

Prerequisite: B.S. in engineering. Study of analysis techniques as applied to specific engineering problems. Applications include beam deflections, acoustics, heat conduction and hydrodynamic stability. (Formerly 4600:660)

**MECE 661 Failure Analysis of Mechanical Systems (3 Units)**

This course emphasizes engineering techniques for predicting yielding, buckling, fracture and fatigue of mechanical systems. Students will be taught how to link theory with practice by examining case studies of structural and mechanical failures and will obtain practical experience in modeling real complex systems in an end-of-term project. (Formerly 4600:661)

**MECE 662 Microscale Heat and Mass Transfer (3 Units)**

Prerequisites: MECE 608 and MECE 615 or permission. Kinetics theory, classical and quantum statistics, structure of solids, phonons in solids, free electrons in metals, Boltzmann transport theory, hyperbolic heat conduction, thermal conductivity of thin films, laser materials processing. (Formerly 4600:662)

**MECE 663 Web-Based Solid Modeling and e-Manufacturing (3 Units)**

Prerequisite: MECE 563 or equivalent or permission. Team-based collaborative design with a web-based solid modeling library, feature-based manufacturing analysis, and process planning using cross-platform interoperable tools including JAVA, VRML for optimized product realization. (Formerly 4600:663)

**MECE 664 Fundamentals of Crystallization and Solidification (3 Units)**

Prerequisite: MECE 608 or equivalent or permission. Fundamental theories and modeling of crystalline nucleation and growth, interface stability and morphology, microstructure formation, and microsegregation. Applications in casting, welding, laser processing, and single crystal growth. (Formerly 4600:664)

**MECE 666 Analysis of Manufacturing Systems (3 Units)**

This course will examine general problems in the design, planning, and control of manufacturing systems. No prerequisites or corequisites are required. (Formerly 4600:666)

**MECE 670 Integrated Flexible Cellular Manufacturing System-Analysis & Design (3 Units)**

Prerequisite: MECE 563 or equivalent or by permission of instructor. The analysis of integrated computer-aided manufacturing systems, design of automated manufacturing components and simulations of flexible cellular manufacturing systems. (Formerly 4600:670)

**MECE 671 Fundamentals and Applications of Micro Electro (3 Units)**

Prerequisite: Consent of instructor. Fundamentals of MEMS based sensors and actuators, MEMS materials, bulk and surface micromachining and MEMS device testing. Applications in optics, automotive, and biomedical instrumentation. (Formerly 4600:671)

**MECE 672 Design of Microsystems and Nano Devices (3 Units)**

Prerequisite: Consent of instructor. Design principles of various micro and nano sensors and actuators, microfluidic devices, microstructure analysis and simulation, microfabrication process design rule. Applications in MOEMS, Lab-on-a-chip devices, BioMEMS and NEMS. (Formerly 4600:672)

**MECE 682 Fundamentals of Composite Processing and Mechanics (3 Units)**

This course covers mainly composite processing, manufacturing and mechanics. The emphasis is on discontinuous fiber composites. (Formerly 4600:682)

**MECE 693 Measurements Methods & Experimental Error in Thermofluid Sciences (3 Units)**

Viscous flow, conduction heat transfer convection heat transfer. The course will incorporate elements of experimental error analysis, optics, and optical ray tracing, principles of testing, methods and devices for fluid flow quantization and temperature measurements. Laboratory work with hands-on experience. (Formerly 4600:693)

**MECE 694 Deformation and Failure of Polymers and Soft Materials (3 Units)**

This course introduces the concepts of deformation, fracture and failure analyses of engineering polymers, soft and biological materials. (Formerly 4600:694)

**MECE 696 Special Topics in Mechanical Engineering (1-4 Units)**

Prerequisite: Permission. For qualified candidate for graduate degree. Supervised research in the student's major field of training or experience. Credit depends upon nature and extent of project as determined by advisor and department chair. (Formerly 4600:696)

**MECE 697 Engineering Report (2 Units)**

Prerequisite: Permission of advisor. A relevant problem in mechanical engineering for students electing the non-thesis option. The final engineering report must be approved by the advisor and the advisory committee. (Formerly 4600:697)

**MECE 698 Master's Research: Mechanical Engineering (1-6 Units)**

Prerequisite: Permission of advisor. (May be repeated.) Research on a suitable topic in mechanical engineering culminating in a master's thesis. (Formerly 4600:698)

**MECE 699 Master's Thesis (1-6 Units)**

Prerequisite: Permission of advisor. (May be repeated). Supervised research in a specific area of mechanical engineering. (Formerly 4600:699)

**MECE 704 Finite Element Analysis II (3 Units)**

Prerequisites: MECE 609 and CIVE 702. Curved, plate, shell, brick elements; quasi-analytical elements. Quadrature formulas. Substructuring for static and dynamic analysis. Solution algorithms for linear and nonlinear static and dynamic analysis. Computer program formulation. Review of large-scale production programs. (Formerly 4600:704)

**MECE 705 Finite Element Analysis III (3 Units)**

Prerequisite: MECE 704. Static and dynamic contact problems. Tire mechanics. Fracture mechanics. Plasticity problems involving small and large deflections. Shake down analysis. General constitutive models for composite media, thermoviscoelasticity, fluid turbulence. Fluid-solid interaction analysis. (Formerly 4600:705)

**MECE 710 Dynamics of Viscous Flow II (3 Units)**

Prerequisite: MECE 610. Introduction to turbulence. Turbulence modeling and turbulent boundary layers. Practical methods of solution of boundary layer problems. Transition process. (Formerly 4600:710)

**MECE 711 Computational Fluid Dynamics II (3 Units)**

Prerequisite: MECE 611 or permission of instructor. Development of advanced computational techniques for convection-dominated flows. Higher order explicit and implicit schemes including nonoscillatory front-capturing methods applied to benchmark problems. (Formerly 4600:711)

**MECE 715 Hydrodynamic Stability (3 Units)**

Prerequisites: MECE 660 and MECE 620 or permission. Stability concepts, Stability of Benard convection, Rayleigh-Taylor flow, parallel shear layers, boundary layers, asymptotic solution of Orr-Sommerfeld equation, nonparallel stability. (Formerly 4600:715)

**MECE 719 Advanced Heat Transfer (3 Units)**

Prerequisites: MECE 615 and MECE 616. Topics include nonhomogeneous or nonlinear boundary value problems of heat conduction, heat transfer with melting, solidification and ablation, heat transfer in porous systems and hydrodynamically and thermally unsteady convection. (Formerly 4600:719)

**MECE 723 Applied Stress Analysis II (3 Units)**

Prerequisite: MECE 623. Continuation of MECE 623. Development of approximate solution techniques including finite elements, method of weighted residuals (Rayleigh-Ritz, Galerkin, Trefftz, collocation, least squares, etc.) and finite differences. (Formerly 4600:723)

**MECE 726 Non-Linear Continuum Mechanics (3 Units)**

Prerequisite: MECE 622. Finite deformation and strain, stress, constitutive equations, strain energy functions. Solution of finite deformation problems in hypoelasticity, coupled thermoviscoelasticity and plasticity, electroelasticity and micropolar theories. (Formerly 4600:726)

**MECE 730 Vibrations of Continuous Systems (3 Units)**

Prerequisite: MECE 630. Continuation of MECE 630. Analysis of continuous vibrating systems, using separation of variables, energy, variational, Rayleigh-Ritz and other approximate techniques. Concepts and solutions of integral equations as applied to continuous systems. (Formerly 4600:730)

**MECE 732 Advanced Modal Analysis of Structures (3 Units)**

Prerequisite: MECE 633 or equivalent. Structural excitation techniques. Modal parameter estimation. System modification; mass/stiffness/damping matrices substructuring. Prediction and evaluation of structural modified dynamic characteristic. (Formerly 4600:732)

**MECE 741 Optimization Theory & Applications (3 Units)**

Prerequisite: Permission. Theory of optimization in engineering systems, development and method of solution optimization problems for physical processes, large systems. Use of dynamic programming, operational research methods of system optimization, control. (Formerly 4600:741)

**MECE 763 Advanced Methods in Engineering Analysis (3 Units)**

Applications of finite difference and finite element methods, variational methods, integral methods and similarity transforms to engineering problems in heat transfers, fluid mechanics and vibrations. (Formerly 4600:763)

**MECE 790 Advanced Seminar in Mechanical Engineering (1-4 Units)**

(May be repeated for a total of nine credits) Prerequisite: permission of department chair. Advanced projects and studies in various areas of mechanical engineering. Intended for student seeking Ph.D in engineering degree. (Formerly 4600:790)

**MECE 898 Preliminary Research (1-15 Units)**

Prerequisite: Approval of dissertation director. Preliminary investigations prior to the submission of a dissertation proposal to the Interdisciplinary Doctoral Committee. (Formerly 4600:898)

**MECE 899 Doctoral Dissertation (1-15 Units)**

(May be taken more than once.) Prerequisite: Acceptance of research proposal by the Interdisciplinary Doctoral Committee and approval by the dissertation director. Original research by the doctoral student. (Formerly 4600:899)