<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>ME 121</td>
<td>Numerical Methods in Mechanical Engineering</td>
<td>Introduction to numerical methods, including error analysis, interpolation, numerical differentiation, and integration.</td>
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<tr>
<td>ME 141</td>
<td>Professional Development I 1 cr.</td>
<td>Focuses on professional development, including ethics, communication, and professional practices.</td>
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<tr>
<td>ME 142</td>
<td>Professional Development II 2 cr.</td>
<td>Continues the professional development theme, focusing on leadership, team dynamics, and project management.</td>
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<tr>
<td>ME 010</td>
<td>Numerical Engineering Fundamentals 3 cr.</td>
<td>Covers fundamental concepts in numerical analysis, including error propagation and computational methods.</td>
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<tr>
<td>ME 017</td>
<td>Demand and Supply in Mechanical Engineering</td>
<td>Explores the concepts of demand and supply, including pricing, inventory management, and market analysis.</td>
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<tr>
<td>ME 021</td>
<td>Fluid Mechanics and Thermodynamics 4 cr.</td>
<td>Covers fluid mechanics and thermodynamics, including fluid properties, flow analysis, and heat transfer.</td>
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<tr>
<td>ME 022</td>
<td>Fluid Mechanics and Thermodynamics 4 cr.</td>
<td>Continues the fluid mechanics and thermodynamics theme, focusing on more advanced topics.</td>
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<tr>
<td>ME 211</td>
<td>Mechanical Engineering Laboratory I 2 cr.</td>
<td>Focuses on laboratory techniques and approaches, including data acquisition and error analysis.</td>
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<tr>
<td>ME 212</td>
<td>Mechanical Engineering Laboratory II 2 cr.</td>
<td>Continues the laboratory techniques theme, including advanced equipment and experimental methods.</td>
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<tr>
<td>ME 231</td>
<td>Manufacturing Systems 3 cr.</td>
<td>Covers manufacturing systems, including process planning, computer-aided manufacturing, and quality control.</td>
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<tr>
<td>ME 240</td>
<td>Fluid Mechanics and Thermodynamics 4 cr.</td>
<td>Explores fluid mechanics and thermodynamics in more depth, focusing on advanced topics.</td>
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<tr>
<td>BIOE 212</td>
<td>Advanced Biomechanics 3 cr.</td>
<td>Focuses on advanced biomechanics, including muscle mechanics, joint kinematics, and human motion.</td>
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<tr>
<td>ENGR 212</td>
<td>Advanced Biomechanics 3 cr.</td>
<td>Continues the advanced biomechanics theme, focusing on more advanced topics.</td>
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<tr>
<td>MATH 033</td>
<td>Advanced Calculus 3 cr.</td>
<td>Focuses on advanced calculus, including multivariable calculus and partial differential equations.</td>
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<tr>
<td>MATH 036</td>
<td>Advanced Calculus 3 cr.</td>
<td>Continues the advanced calculus theme, focusing on more advanced topics.</td>
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<tr>
<td>MECH 012</td>
<td>Advanced Engineering Mechanics 3 cr.</td>
<td>Covers advanced engineering mechanics, including force systems, kinematics, and dynamics.</td>
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<tr>
<td>MECH 102</td>
<td>Advanced Engineering Mechanics 3 cr.</td>
<td>Continues the advanced engineering mechanics theme, focusing on more advanced topics.</td>
</tr>
<tr>
<td>CIVL 205</td>
<td>Advanced Structural Analysis 3 cr.</td>
<td>Focuses on advanced structural analysis, including finite element analysis and stability analysis.</td>
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<tr>
<td>CIVL 206</td>
<td>Advanced Structural Analysis 3 cr.</td>
<td>Continues the advanced structural analysis theme, focusing on more advanced topics.</td>
</tr>
<tr>
<td>CIVL 207</td>
<td>Advanced Structural Analysis 3 cr.</td>
<td>Explores advanced structural analysis in greater depth, focusing on specialized topics.</td>
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Credits: The course load is impacted by the number of credit hours awarded for each course. The total number of credit hours needed for graduation is usually 120. Students must also complete general education requirements and major-specific courses.
ME 255 Introduction to Aerospace Engineering 3 Credits
An introductory course in the core engineering principles used in the aerospace industry: aerodynamics, controls, propulsion, and structures. The course is designed for any engineering student who may intend to work in the aerospace industry and develops a basic understanding of the technologies used in the design and operation of today’s aircraft, rockets, and spacecraft.
Prerequisites: ME 104

ME 299 Special Topics In Mechanical Engineering 1-4 Credits
Repeat Status: Course may be repeated.

ME 300 Apprentice Teaching 1-3 Credits
Repeat Status: Course may be repeated.

ME 304 Thermodynamics II 3 Credits
Prerequisites: ME 104

ME 309 (MAT 309) Composite Materials 3 Credits
Principles and technology of composite materials. Processing, properties, and structural applications of composites, with emphasis on fiber-reinforced polymers.
Prerequisites: MECH 003 and MAT 033

ME 310 (TE 310) Directed Study 1-3 Credits
Project work on any aspect of engineering, performed either individually or as a member of a team made up of students, possibly from other disciplines. Project progress is reported in the form of several planning and project reports. Direction of the projects may be provided by faculty from several departments and could include interaction with outside consultants and local communities and industries. Consent of department required.
Repeat Status: Course may be repeated.

ME 312 Analysis and Synthesis Of Mechanisms 3 Credits
Types of motion. Degrees of freedom of motion. Position, velocity and acceleration analysis of linkage mechanisms. Systematic approach to the design of linkage mechanisms. Motion generation, path synthesis and function synthesis. Structural synthesis of planar and spatial mechanisms. Static force analysis of mechanisms using virtual work.
Prerequisites: MATH 205 and MECH 102

ME 314 (MAT 314) Metal Forming Processes 3 Credits

ME 315 (BIOE 315) Bioengineering Statistics 3 Credits
Probability and statistics applied to bioengineering problems focusing on modeling and data analysis. Types of data, types of distributions, parametric and nonparametric analyses, goodness-of-fit, regression, power analysis, and multivariate analysis, life models, simulation, cluster analysis, and Bayesian statistics. Projects and case studies.
Prerequisites: MATH 231

ME 316 (BIOE 316) Introduction to Force Spectroscopy 3 Credits
Fundamentals of major force spectroscopy methods, including atomic force microscopy, optical tweezers, and magnetic tweezers. Principles of force measurement, force calibration, and signal and noise. Applications to the mechanical properties of biomaterials, such as polymer elasticity, protein folding, nanoindentation, and structural transitions in macromolecules. Closed to students who have taken BIOE 416.
Prerequisites: MECH 003

ME 321 Introduction to Heat Transfer 3 Credits
Analytical and numerical solutions to steady and transient one-and two-dimensional conduction problems. Forced and natural convection in internal and external flows. Thermal radiation. Thermal design of engineering processes and systems.
Prerequisites: ME 104 and ME 231

ME 322 Gas Dynamics 3 Credits
Prerequisites: ME 231 and ME 104

ME 323 Reciprocating and Centrifugal Engines 3 Credits
Thermal analysis and design of internal combustion engines (conventional and unconventional), gas turbine engines, air breathing jet engines, and rockets. Components such as jet nozzles, compressors, turbines, and combustion chambers are chosen to exemplify the theory and development of different types of components. Both ideal fluid and real fluid approaches are considered.
Prerequisites: ME 104

ME 331 Advanced Fluid Mechanics 3 Credits
Prerequisites: ME 231

ME 333 Propulsion Systems 3 Credits
Review of jet and rocket engine technologies. Jet and rocket engine thermodynamic and aerodynamic principles. Performance of turbojet, turbofan, and turboprop jet engines. Rocket engines include liquid, cryogenic, solid, and electric propulsion.
Prerequisites: ME 104 and MECH 326
Can be taken Concurrently: MECH 326

ME 340 Advanced Mechanical Design 3 Credits
Probabilistic design of mechanical components and systems. Reliability functions, hazard models and product life prediction. Theoretical stress-strength-time models. Static and dynamic reliability models. Optimum design of mechanical systems for reliability objectives or constraints.

ME 341 Mechanical Systems 3 Credits
Prerequisites: ME 252

ME 342 Dynamics of Engineering Systems 3 Credits
Dynamic analysis of mechanical, electromechanical, fluid and hybrid engineering systems with emphasis on the modeling process. Lumped and distributed-parameter models. Use of computer tools for modeling, design and simulation. Design projects.
Prerequisites: ME 242

ME 343 Control Systems 3 Credits
A comprehensive course in classical and modern linear control systems. Includes root locus, frequency response, state space, and digital control techniques with extensive use of computational methods. A design project provides experience with practical design issues and tradeoffs.
Prerequisites: ME 242 or ECE 125 or ME 245

ME 348 Computer-Aided Design 3 Credits
Impact of computer-aided engineering tools on mechanical design and analysis. Part geometry modeling and assembly modeling using solid representations. Analysis for mass properties, interference, kinematics, displacements, stresses and system dynamics by using state-of-the-art commercially available computer-aided-engineering software. Integrated design projects.
Prerequisites: ME 010 and MECH 012 and MECH 102 and MATH 205
ME 350 Special Topics 1-5 Credits
A study of some field of mechanical engineering not covered elsewhere. Consent of department chair required.
Repeat Status: Course may be repeated.

ME 354 Automatic Control of Aerospace Vehicles 3 Credits
The forces and moments acting on rigid aircraft are developed from basic aerodynamics and used to determine the equations of motion and the resulting dynamic models. Analysis from these dynamic models supports the design of flight control, guidance, and autopilot systems. Modern control methods for missiles and spacecraft are also included. Undergraduate course assumes rigid airplane structures, while the graduate course develops the effects of flexible structures.
Prerequisites: MECH 326 and ME 343

ME 355 Spacecraft Systems Engineering 3 Credits
Systems engineering approach to design, integration, testing, and operations of spacecraft for various missions. Technologies currently used in modern spacecraft bus and payload systems, astrodynamics, launch systems, life-cycle costs, and operational issues. Team works to design a spacecraft that meets a specific set of mission requirements.
Prerequisites: ME 255

ME 356 Astrodynamics 3 Credits
Kepler's Laws are discussed and proven from basic mechanics, then used to determine the equations of motion for a satellite. Subsequent topics include various kinds of orbits in use today, orbit determination, orbital maneuvers, and rendezvous. Interplanetary trajectories, satellite attitude dynamics, rocket vehicles, and orbital perturbations are also discussed.
Prerequisites: MECH 102

ME 360 Nuclear Reactor Engineering 3 Credits
A consideration of the engineering problems related to nuclear reactor design and operation. Topics include fundamental properties of atomic and nuclear radiation, reactor fuels and materials, reactor design and operation, thermal aspects, safety and shielding, instrumentation and control. Course includes several design projects stressing the major topics in the course. Must have senior standing in engineering or physical science.

ME 362 Nuclear Fusion and Radiation Protection 3 Credits

ME 364 Renewable Energy 3 Credits
Fundamentals and design aspects of Renewable Energy (RE) technologies: biofuels, hydropower, solar photovoltaic, solar thermal, wind, geothermal energies. Details and difficulties in implementing RE. Senior standing in Engineering. Credit not given for both ME 364 and ME 464.
Prerequisites: ME 104 and ME 231

ME 366 Power Generation Technologies 3 Credits
The energy matrix is changing due to economic, environmental, and political pressure, requiring a transition to become more efficient, carbon-neutral, resilient, and competitive. This course looks at the design and performance of conventional (coal and natural gas) power generation systems, including thermal cycles, power plant efficiency, technologies for environmental compliance, carbon capture and sequestration, plant flexibilization and energy storage, and advanced plant data analytics. Must have junior standing in engineering or physical science.

ME 368 Fundamentals of Energy Efficiency Practicium 3 Credits
Studies of the plant operation and energy usage. Students work with the Lehigh Industrial Assessment Center to do technical and economic feasibility studies of optimizing energy consumption. Industrial experience. Fundamentals of best practices to save energy, reduce waste, and increase productivity. Consent of instructor required.
Prerequisites: ME 104 and ME 231

ME 373 Mechatronics 3 Credits
Synergistic integration of mechanical engineering with electronics and intelligent computer control in designing and manufacturing machines, products and processes; semiconductor electronics, analog signal processing, with op amps, digital circuits, Boolean algebra, logic network designs, Karnaugh map, flip-flops and applications, data acquisition, A/D and D/A, interfacing to personal computers, sensors and actuators, microcontroller programming and interfacing.

ME 374 Mechatronics Laboratory 3 Credits
Experiments and applications utilizing combinations of mechanical, electrical, and microprocessor components. Theory and application of electronic and electromechanical equipment, operation and control of mechatronic systems. Projects integrating mechanical, electronic and microcontrollers.

ME 376 (CHE 376) Energy: Issues & Technology 3 Credits
Energy usage and supply, fossil fuel technologies, renewable energy alternatives and environmental impacts. The scope will be broad to give some perspective of the problems, but in-depth technical analysis of many aspects will also be developed.
Prerequisites: CHE 210 or ME 104 or CHM 342 or MAT 205

ME 385 Polymer Product Manufacturing 3 Credits
Polymer processes such as injection molding through a combination of theory development, practical analysis, and utilization of commercial software. Polymer chemistry and structure, material rheological behavior, processing kinetics, molecular orientation development, process simulation software development, manufacturing defects, manufacturing window establishment, manufacturing process design, manufacturing process optimization. Must have senior level standing in engineering or science. Credit not given for both ME 385 and ME 485.

ME 387 (CHE 387, ECE 387) Digital Control 3 Credits
Sampled-data systems: z-transforms; pulse transfer functions; stability in the z-plane; root locus and frequency response design methods; minimal prototype design; digital control hardware; discrete state variables; state transition matrix; Liapunov stability state feedback control (two lectures and one laboratory per week).
Prerequisites: CHE 386 or ECE 212 or ME 343

ME 388 Honors Project for Eckardt Scholar 1-4 Credits
Opportunity for Eckardt Scholars to pursue an extended project for senior honors.Transcript will identify department in which project was completed.
Repeat Status: Course may be repeated.

ME 389 (CHE 389, ECE 389) Control Systems Laboratory 2 Credits
Experiments on a variety of mechanical, electrical and chemical dynamic control systems. Exposure to state-of-the-art control instrumentation: sensors, transmitters, control valves, analog and digital controllers. Emphasis on design of feedback controllers and comparison of theoretical computer simulation predictions with actual experimental data. Lab teams will be interdisciplinary.
Prerequisites: CHE 386 or ECE 212 or ME 343

ME 401 (MSE 401) Integrated Product Development 3 Credits
An integrated and interdisciplinary approach to engineering design, concurrent engineering, design for manufacturing, industrial design and the business of new product development. Topics include: design methods, philosophy and practice, the role of modeling and simulation, decision making, risk, cost, material and manufacturing process selection, platform and modular design, mass customization, quality, planning and scheduling, business issues, teamwork, group dynamics, creativity and innovation. The course uses case studies and team projects. ME 402.
ME 402 (MAT 402) Advanced Manufacturing Science 3 Credits
The course focuses on the fundamental science-base underlying manufacturing processes, and applying that science base to develop knowledge and tools suitable for industrial utilization. Selected manufacturing processes representing the general classes of material removal, material deformation, material phase change, material flow, and material joining are addressed. Students create computer-based process simulation tools independently as well as utilize leading commercial process simulation packages. Laboratory experiences are included throughout the course.

ME 411 Boundary-Layer Theory 3 Credits
The course is intended as a first graduate course in viscous flow. An introduction to boundary-layer theory, thermodynamics and heat transfer at the undergraduate level are assumed to have been completed. Topics include the fundamental equation of continuum fluid mechanics, the concept of asymptotic methods and low and high Reynolds number flows, laminar boundary layers, generalized similarity methods, two-and three-dimensional flows, steady and unsteady flows and an introduction to hydrodynamic stability. The material is covered in the context of providing a logical basis as an introduction to a further course in turbulent flows.

ME 413 Numerical Methods in Mechanical Engineering 3 Credits

ME 415 Flow-Induced Vibrations 3 Credits

ME 420 Advanced Thermodynamics 3 Credits

ME 421 Topics in Thermodynamics 3 Credits
Emphasis on theoretical and experimental treatment of combustion processes including dissociation, flame temperature calculations, diffusion flames, stability and propagation; related problems in compressible flow involving one-dimensional, oblique shock waves and detonation waves. Methods of measurement and instrumentation.

ME 423 Heat and Mass Transfer 3 Credits
This course is a first graduate course in the basic concepts of heat and mass transfer, providing a broad coverage of key areas in diffusion, conduction, convection, heat and mass transfer, and radiation. Topics covered include: the conservation equations, steady and transient diffusion and conduction, periodic diffusion, melting and solidification problems, numerical methods, turbulent convection, transpiration and film cooling, free convection, heat transfer with phase change, heat exchanges, radiation, mixed mode heat and mass transfer.

ME 424 Unsteady and Turbulent Flow 3 Credits
Stability of laminar flow; transition to turbulence. Navier-Stokes equations with turbulence. Bounded turbulent shear flows; free shear flows; statistical description of turbulence.

ME 426 Radiative and Conductive Heat Transfer 3 Credits
Principles of radiative transfer; thermal-radiative properties of diffuse and specular surfaces; radiative exchange between bodies; radiative transport through absorbing, emitting and scattering media. Advanced topics in steady-state and transient conduction; analytical and numerical solutions; problems of combined conductive and radiative heat transfer.

ME 428 Boundary Layers and Convective Heat Transfer 3 Credits
Navier-Stokes and energy equations, laminar boundary layer theory, analysis of friction drag, transfer and separation. Transition from laminar to turbulent flow. Turbulent boundary layer theory. Prandtl mixing length, turbulent friction drag, and heat transfer. Integral methods. Flow in ducts, wakes and jets. Natural convection heat transfer.

ME 430 Advanced Fluid Mechanics 3 Credits
This course is a first graduate course in incompressible fluid mechanics, providing a broad coverage of key areas of viscous and inviscid fluid mechanics. Topics covered include: Flow kinematics, differential equations of motion, viscous and inviscid solutions, vorticity dynamics and circulation, vorticity equation, circulation theorems, potential flow behavior, irrotational and rotational flows, simple boundary layer flows and solutions, and real fluid flows and consequences.

ME 431 Advanced Gas Dynamics 3 Credits

ME 433 (CHE 433, ECE 433) Linear Systems and Control 3 Credits
This course covers the following topics in linear systems and control theory: review of fundamental concepts in linear algebra, state-space representation of linear systems, linearization, time-variance and linearity properties of systems, impulse response, transfer functions and their state-space representations, solution to LTI and LTV state equations, Jordan form, Lyapunov stability, input-output stability, controllability, stabilizability, observability, detectability, Canonical forms, minimal realizations, introduction to optimal control theory, Linear Quadratic Regulator (LQR), Algebraic Riccati Equation (ARE), frequency domain properties of LQR controllers.

ME 434 (CHE 434, ECE 434) Multivariable Process Control 3 Credits
A state-of-the-art review of multivariable methods of interest to process control applications. Design techniques examine include loop interaction analysis, frequency domain methods (Inverse Nyquist Array, Characteristic Loci and Singular Value Decomposition) feed forward control, internal model control and dynamic matrix control. Special attention is placed on the interaction of process design and process control. Most of the above methods are used to compare the relative performance of intensive and extensive variable control structures.

Prerequisites: CHE 433 or ME 433 or ECE 433

ME 436 (CHE 436, ECE 436) Systems Identification 3 Credits
The determination of model parameters from time-history and frequency response data by graphical, deterministic and stochastic methods. Examples and exercises taken from process industries, communications and aerospace testing. Regression, quasilinearization and invariant-imbedding techniques for nonlinear system parameter identification included.

ME 437 (CHE 437, ECE 437) Stochastic Control 3 Credits

Prerequisites: CHE 433 or ME 433 or ECE 433

ME 440 General Examination 3 Credits
A critical assessment and definition of major unresolved issues for an assigned research topic during the first half of the semester, followed by formulation of a research proposal in accord with the format of a federal funding agency during the second half of the semester. In addition to the written proposal, the student gives a presentation to the Doctoral Committee, followed by extensive discussion. Grade assigned by the committee; minimum grade of B+ required. Instructor (doctoral student adviser) approval required.
ME 444 Experimental Stress Analysis in Design 3 Credits
Fundamental concepts of strain measurements and application of strain gages and strain gage circuits. Two- and three-dimensional photoelasticity; stress separation techniques, birefringent coatings, moiré methods, caustics. Use of image analysis in data acquisition and interpretation. Selected laboratory experiments.

ME 446 Mechanical Reliability 3 Credits

ME 450 Special Topics 3 Credits
An intensive study of some field of mechanical engineering not covered in more general courses.

Repeat Status: Course may be repeated.

ME 452 (BIOE 452, CHE 452, ENGR 452) Mathematical Methods In Engineering I 3 Credits
Analytical techniques relevant to the engineering sciences are described. Vector spaces; eigenvalues; eigenvectors. Linear ordinary differential equations; diagonalizable and non-diagonalizable systems. Inhomogeneous linear systems; variation of parameters. Nonlinear systems; stability; phase plane. Series solutions of linear ordinary differential equations; special functions. Laplace and Fourier transforms; application to partial differential equations and integral equations. Sturm-Liouville theory. Finite Fourier transforms; planar, cylindrical, and spherical geometries.

ME 453 Mathematical Methods in Engineering II 3 Credits

ME 454 Automatic Control of Aerospace Vehicles 3 Credits
The forces and moments acting on aircraft are developed from basic aerodynamics and used to determine the equations of motion and the resulting dynamic models. Analysis from these dynamic models supports the design of flight control, guidance, and autopilot systems. Modern control methods for missiles and spacecraft are also included. Effects of flexible structures are developed. Cannot receive credit if previously completed ME 354.
Prerequisites: MECH 326 and MECH 343

ME 458 Modeling of Dynamic Systems 3 Credits
Modeling of complex linear and nonlinear energetic dynamic engineering systems. Emphasis on subdivision into multiport elements and representation by the bondgraph language using direct, energetic, and experimental methods. Field lumping. Analytical and graphical reductions. Simulation and other numerical methods. Examples including mechanisms, electromechanical transducers, electric and fluid circuits, and thermal systems.

ME 460 Engineering Project 1-6 Credits
Project work on some aspect of mechanical engineering in an area of student and faculty interest. Selection and direction of the project could involve interaction with local communities or industries. Consent of department required.
Repeat Status: Course may be repeated.

ME 461 Integrated Product Development (IPD) Projects 1-2 Credits
Technical and economic feasibility study of new products. Selection and content of the project is determined by the faculty project advisor in consultation with the student. progress and final reports, oral and posters presentations. Consent of the program director and faculty project advisor required.
Prerequisites: TE 401 or ME 401

ME 462 IPD: Manufacturing 3 Credits
Industry sponsored Integrated Product Development Project (IPD) projects. The student works with an industry sponsor to create detailed design specifications, fabricate and test a prototype new product and plan for production. Selection and content of the project is determined by the faculty project advisor in consultation with the industry sponsor. Deliverables include progress and final reports, oral presentations, posters and a prototype. Consent of the department chair and faculty project advisor required.

ME 464 Renewable Energy 3 Credits
Fundamentals and design aspects of Renewable Energy (RE) technologies; bio-fuels, hydropower, solar photovoltaic, solar thermal, wind, geothermal energies. Details and difficulties in implementing RE. ME 464 is graduate level version of ME 364 and will require additional assignments and/or projects appropriate for graduate level study. Closed to students who have taken ME 364.

ME 466 Fundamentals of Acoustics 3 Credits

ME 468 Advanced Energy Efficiency Practicum 3 Credits
Critical assessments of energy management systems. Establishment of framework for industrial facilities to manage energy systems. Fundamentals of best practices for energy efficiencies associated with industrial energy savings. Progress and final reports required. Engineering graduate students only. Consent of instructor required.

ME 475 Directed Studies 1-3 Credits
Special problems related to a topic in mechanical engineering and mechanics.

ME 485 Polymer Product Manufacturing 3 Credits
An exploration of the science underlying polymer processes such as injection molding through a combination of theory development, practical analysis, and utilization of commercial software. Polymer chemistry and structure, material rheological behavior, processing kinetics, molecular orientation development, process simulation software development, manufacturing defects, manufacturing window establishment, manufacturing process design, manufacturing process optimization. This course is a version of ME 385 for graduate students, with research projects and advanced assignments. Closed to students who have taken ME 385. Must have graduate level standing in engineering or science.

ME 490 Thesis 1-6 Credits
Repeat Status: Course may be repeated.

ME 499 Dissertation 1-15 Credits
Repeat Status: Course may be repeated.