Mechanical engineering is a highly diversified profession. The mechanical engineer designs machines, devices, various products and control systems, and works with the generation, conversion, transmission, and utilization of mechanical and thermal power. Assignments often include analysis and synthesis of mechanical, thermal, and fluid systems. Mechanical engineers are also responsible for characterization, specification, and analysis of materials used in design and manufacturing. Manufacturing systems, robotics, electromechanical devices, and control systems are also the purview of the mechanical engineer. Graduates in mechanical engineering are among the most versatile engineers and enjoy professional employment in industry, government, consulting, and research organizations. The undergraduate program in Mechanical Engineering at Texas A&M University is accredited by the Engineering Accreditation Commission of ABET, www.abet.org.

The work of mechanical engineers varies from general engineering to numerous, narrow specialties, as required by the wide variety of employers. A general list, though not in any way exhaustive, of the areas of professional employment opportunities available to mechanical engineers includes: design, construction, controls, materials specification and evaluation, analysis of thermal systems, fluid and solid mechanics, manufacturing, plant engineering, research and development, and technical sales. Many mechanical engineers are promoted to management and administrative positions as well.

The mission of the Department of Mechanical Engineering is to serve the students of Texas A&M University, the State of Texas, and the nation by:

• providing quality education that is well-grounded in the fundamental principles of engineering, fostering innovation and preparing students for leadership positions and successful careers in industry, government, and academia;
• advancing the knowledge base of mechanical engineering to support the competitiveness of existing industry and to spawn new economic development in Texas and the nation through active involvement in basic and applied research in a global context; and
• successfully pursue life-long learning and advanced study opportunities, and subsequently contribute to the development of advanced concepts and leading edge technologies.

The objectives of the Mechanical Engineering program are to produce graduates who will:

• have successful careers, and become leaders, in industry and the public sector;
• appropriately apply acquired knowledge, work well with other people, effectively communicate ideas and technical information, and continue to learn and improve; and
• successfully pursue advanced studies, if they so choose, opportunities, and subsequently contribute to the development of advanced concepts and leading edge technologies.

The educational outcomes for the Mechanical Engineering program are that students will attain:

• an ability to apply knowledge of mathematics, science and engineering;
• an ability to design and conduct experiments, as well as to analyze and interpret data;
• an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability;
• an ability to function on multi-disciplinary teams;
• an ability to identify, formulate and solve engineering problems;
• an understanding of professional and ethical responsibility;
• an ability to communicate effectively;
• the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context;
• a recognition of the need for, and an ability to engage in life-long learning;
• a knowledge of contemporary issues; and
• an ability to use the techniques, skills and modern engineering tools necessary for engineering practice.

Mechanical engineers should possess a thorough understanding of engineering science as well as analytical and practical skills in one of many basic mechanical engineering specialties. The mechanical engineering curriculum at Texas A&M requires students to develop and apply logical thinking, innovative approaches, and ethical standards as a prerequisite for professional competence. The curriculum consists of basic theory courses complemented by laboratory experiences in dynamic systems and controls, design, experimentation, fluid mechanics, heat transfer, manufacturing, and materials. Elective courses are offered in numerous areas including air conditioning, automotive engineering, computer-aided design, control systems, corrosion, energy conversion, internal combustion engines, manufacturing, materials, mechanical design, polymers, mechatronics, metallurgy, power generation, robotics, stress analysis, fluid mechanics, turbomachinery, and others. The selection of elective courses is dictated by the interests and goals of the student, working with departmental advisors and within the curriculum guidelines.

Many students enhance their education by participating in cooperative education and/or professional internships, which offer opportunities for employment in engineering positions while working toward a degree. Numerous study abroad programs are also available for gaining experience and perspectives in the international arena. Participation in student chapters of professional and honor societies provides leadership opportunities, collegial activities, and learning experiences outside the classroom. Many students also participate in research projects through individual directed studies courses with a professor. The mechanical engineering program culminates with a senior capstone design course sequence highlighted by real-life projects sponsored by various industries. Students benefit from the challenges and gratification that come through direct interaction with practicing engineers.

Before commencing course work in the major, students must be admitted to the major or have the approval of the department.
Faculty

Allaire, Douglas L, Assistant Professor
Mechanical Engineering
PHD, Massachusetts Institute of Technology, 2009

Amini, Noushin, Visiting Assistant Professor
Mechanical Engineering
PHD, Texas A&M University, 2011

Anand, Nagamangala, Professor
Mechanical Engineering
PHD, Purdue University, 1983

Annamalai, Kalyan, Professor
Mechanical Engineering
PHD, Georgia Institute of Technology, 1975

Banerjee, Debjyoti, Professor
Mechanical Engineering
PHD, University of California, Los Angeles, 1999

Caton, Jerald A, Professor
Mechanical Engineering
PHD, Massachusetts Institute of Technology, 1980

Charoenphol, Phapanin, Research Assistant Professor
Mechanical Engineering
DEN, University of Michigan, 2012

Childs, Dara W, Professor
Mechanical Engineering
PHD, The University of Texas at Austin, 1968

Chowdhury, Shahla, Lecturer
Mechanical Engineering
MS, University of Illinois at Urbana-Champaign, 2013
MS, Bangladesh University of Engineering & Technology, 2009

Claridge, David E, Professor
Mechanical Engineering
PHD, Stanford University, 1976

Cope, Dale A, Associate Professor of the Practice
Mechanical Engineering
PHD, Wichita State University, 2002

Darbha, Swaroop V, Professor
Mechanical Engineering
PHD, University of California, Berkeley, 1994

Delgado, Adolfo, Associate Professor
Mechanical Engineering
PHD, Texas A&M University, 2008

Donnell, James M, Professor of the Practice
Mechanical Engineering
BS, Texas A&M University, 1982

Doron, Yuval, Lecturer
Mechanical Engineering
MS, Texas A&M University, 2009

Felts, Jonathan R, Assistant Professor
Mechanical Engineering
PHD, University of Illinois at Urbana-Champaign, 2013

Freed, Alan D, Professor
Mechanical Engineering
PHD, University of Wisconsin - Madison, 1985

Gonezen, Sevan, Assistant Professor
Mechanical Engineering
PHD, Rensselaer Polytechnic Institute, 2011

Gopalswamy, Swaminathan, Professor of the Practice
Mechanical Engineering
PHD, University of California, Berkeley, 1991

Grunlan, Jaime C, Professor
Mechanical Engineering
PHD, University of Minnesota, Twin Cities, 2001

Gu, Lili, Visiting Assistant Professor
Mechanical Engineering
PHD, Tsinghua University, China, 2015

Haglund, John S, Senior Lecturer
Mechanical Engineering
PHD, Texas A&M University, 2003

Hajimirza, Shima, Assistant Professor
Mechanical Engineering
PHD, Texas A&M University, 2013

Han, Je C, Distinguished Professor
Mechanical Engineering
PHD, Massachusetts Institute of Technology, 1977

Hogan, Harry A, Professor
Mechanical Engineering
PHD, Texas A&M University, 1984

Hur, Pilwon, Assistant Professor
Mechanical Engineering
PHD, University of Illinois at Urbana-Champaign, 2010

Jacobs, Timothy J, Professor
Mechanical Engineering
PHD, University of Michigan, 2005

Kim, Haejune, Research Assistant Professor
Mechanical Engineering
PHD, University of Wisconsin - Milwaukee, 2014

Kim, Won-Jong, Associate Professor
Mechanical Engineering
PHD, Massachusetts Institute of Technology, 1997

Kim, Yong-Joe, Associate Professor
Mechanical Engineering
PHD, Purdue University, 2003

Kulatilaka, Waruna D, Associate Professor
Mechanical Engineering
PHD, Purdue University, 2006
Lau, Sai C, Professor
Mechanical Engineering
PHD, University of Minnesota, Twin Cities, 1980

Layton, Astrid C, Assistant Professor
Mechanical Engineering
PHD, Georgia Institute of Technology, 2014

Lee, Sungyon, Assistant Professor
Mechanical Engineering
PHD, Massachusetts Institute of Technology, 2010

Li, Ying, Associate Professor
Mechanical Engineering
PHD, University of Florida, 2007

Liang, Hong, Professor
Mechanical Engineering
PHD, Stevens Institute of Technology, 1992

Malak, Richard J, Associate Professor
Mechanical Engineering
PHD, Georgia Institute of Technology, 2008

McAdams, Daniel A, Professor
Mechanical Engineering
PHD, The University of Texas at Austin, 1999

McVay, Matilda W, Instructional Associate Professor
Mechanical Engineering
PHD, Texas A&M University, 1996

Moreno, Michael R, Assistant Professor
Mechanical Engineering
PHD, Texas A&M University, 2009

Muliana, Hanifah, Professor
Mechanical Engineering
PHD, Georgia Institute of Technology, 2004

Ozkan, Tanil, Instructional Assistant Professor
Mechanical Engineering
DEN, University of Illinois at Urbana-Champaign, 2014

Pagilla, Prabhakar R, Professor
Mechanical Engineering
PHD, University of California, Berkeley, 1996

Palazzolo, Alan B, Professor
Mechanical Engineering
PHD, University of Virginia, 1981

Pate, Michael B, Professor
Mechanical Engineering
PHD, Purdue University, 1982

Petersen, Eric L, Professor
Mechanical Engineering
PHD, Stanford University, 1998

Pharr, George, Assistant Professor
Mechanical Engineering
PHD, Harvard University, 2014

Polycarpou, Andreas A, Professor
Mechanical Engineering
PHD, State University of New York at Buffalo, 1994

Rajagopal, Kumbakonam, Distinguished Professor
Mechanical Engineering
PHD, University of Minnesota, Twin Cities, 1978

Rasmussen, Bryan P, Associate Professor
Mechanical Engineering
PHD, University of Illinois at Urbana-Champaign, 2005

Rathinam, Sivakumar, Associate Professor
Mechanical Engineering
PHD, University of California, Berkeley, 2007

Reddy, Junuthula N, Distinguished Professor
Mechanical Engineering
PHD, The University of Alabama in Huntsville, 1974

Ryu, Seok Chang, Assistant Professor
Mechanical Engineering
PHD, Stanford University, 2013

Sanandres, Luis A, Professor
Mechanical Engineering
PHD, Texas A&M University, 1985

Saripalli, Srikant, Associate Professor
Mechanical Engineering
PHD, University of Southern California, 2007

Schobeiri, Taher M, Professor
Mechanical Engineering
PHD, Technische Universitat Darmstadt, Germany, 1979

Srinivasa, Arun R, Professor
Mechanical Engineering
PHD, University of California, Berkeley, 1991

Staack, David A, Associate Professor
Mechanical Engineering
PHD, Drexel University, 2008

Suh, Chii-Der, Associate Professor
Mechanical Engineering
PHD, Texas A&M University, 1997

Tai, Li-Jung, Assistant Professor
Mechanical Engineering
PHD, University of Michigan, 2011

Tsenn, Joanna N, Instructional Assistant Professor
Mechanical Engineering
PHD, Texas A&M University, 2016

Vinayak, Fnu, Assistant Professor
Mechanical Engineering
PHD, Purdue University, 2016

Wen, Sy-Bor, Associate Professor
Mechanical Engineering
PHD, University of California, Berkeley, 2006
May be repeated 2 times for credit.

**MEEN 285 Directed Studies**

Credits 1 to 4. 1 to 4 Other Hours.

Directed studies in specific problem areas of mechanical engineering.

**Prerequisites:** MEEN classification; approval by instructor and department head or delegate.

**MEEN 289 Special Topics in...**

Credits 0 to 4. 0 to 4 Other Hours.

Selected topics in an identified area of mechanical engineering. May be repeated for credit.

**Prerequisite:** Approval of instructor.

**MEEN 291 Research**

Credits 1 to 4. 1 to 4 Other Hours.

Research conducted under the direction of faculty member in mechanical engineering. May be repeated 2 times for credit.

**Prerequisites:** Freshman or sophomore classification and approval of instructor.

**MEEN 315 Principles of Thermodynamics**

Credits 3. 3 Lecture Hours.

Theory and application of energy methods in engineering; conservation of mass and energy; energy transfer by heat, work and mass; thermodynamic properties; analysis of open and closed systems; the second law of thermodynamics and entropy; gas, vapor and refrigeration cycles.

**Prerequisites:** MEEN 225; MATH 251 or MATH 253; junior or senior classification.

**MEEN 344 Fluid Mechanics**

Credits 3. 3 Lecture Hours.

Application of laws of statics, buoyancy, stability, energy and momentum to behavior of ideal and real fluids; dimensional analysis and similitude and their application to flow through ducts and piping; lift and drag and related problems.

**Prerequisites:** MEEN 225 and MEEN 315.

**MEEN 345 Fluid Mechanics Laboratory**

Credit 1. 3 Lab Hours.

Introduction to basic fluid mechanics instrumentation; experimental verification and reinforcement of the analytical concepts introduced in MEEN 344.

**Prerequisites:** MEEN 260; MEEN 344 or registration therein.

**MEEN 357 Engineering Analysis for Mechanical Engineers**

Credits 3. 3 Lecture Hours.

Practical foundation for the use of numerical methods to solve engineering problems: Introduction to Matlab, error estimation, Taylor series, solution of non-linear algebraic equations and linear simultaneous equations; numerical integration and differentiation; initial value and boundary value problems; finite difference methods for parabolic and elliptic partial differential equations.

**Prerequisites:** ENGR 112 and MATH 308; MEEN 210 or concurrent enrollment.
MEEN 360 Materials and Manufacturing Selection in Design
Credits 3. 3 Lecture Hours.
Selecting materials and manufacturing processes in design; emphasis on material mechanical properties; microstructure production and control; manufacturing processes for producing various shapes for components and structures; use of design methodology.
Prerequisites: MEEN 210, MEEN 222/MSEN 222, MEEN 260; CVEN 305; junior or senior classification.

MEEN 361 Materials and Manufacturing in Design Laboratory
Credit 1. 3 Lab Hours.
Experiments in materials characterization and manufacturing processes; emphasis on material mechanical properties; microstructure production and control; manufacturing processes for producing various shapes for components and structures.
Prerequisites: MEEN 222/MSEN 222, MEEN 260; CVEN 305; MEEN 360 or registration therein; junior or senior classification or approval of instructor.

MEEN 363 Dynamics and Vibrations
Credits 3. 2 Lecture Hours. 2 Lab Hours.
Dynamics and Vibration. Application of Newtonian and energy methods to model dynamic systems (particles and rigid bodies) with ordinary differential equations; solution of models using analytical and numerical approaches; interpreting solutions; linear vibrations.
Prerequisites: MEEN 225; MATH 308; MEEN 357 or concurrent enrollment; CVEN 305 or concurrent enrollment.

MEEN 364 Dynamic Systems and Controls
Credits 3. 2 Lecture Hours. 3 Lab Hours.
Mathematical modeling, analysis, measurement and control of dynamic systems; extensions of modeling techniques of MEEN 363 to other types of dynamic systems; introduction to feedback control, time and frequency domain analysis of control systems, stability, PID control, root locus; design and implementation of computer-based controllers in the lab.
Prerequisites: MEEN 260 and MEEN 363; ECEN 215.

MEEN 368 Solid Mechanics in Mechanical Design
Credits 3. 2 Lecture Hours. 2 Lab Hours.
Stress analysis of deformable bodies and mechanical elements; stress transformation; combined loading; failure modes; material failure theories; fracture and fatigue; deflections and instabilities; thick cylinders; curved beams; design of structural/mechanical members; design processes.
Prerequisites: CVEN 305; MEEN 357 and MEEN 360 or registration therein; junior or senior classification.

MEEN 381 Seminar
Credit 1. 2 Other Hours.
Presentations by practicing engineers and faculty addressing: effective communications, engineering practices, professional registration, ethics, career-long competence, contemporary issues, impact of technology on society and being informed; preparation of a resume, a lifelong learning plan, two papers, two oral presentations and complete an online assessment of the mechanical engineering program.
Prerequisite: Upper-level classification in mechanical engineering.

MEEN 399 High Impact Experience for Mechanical Engineers
Credits 0. 0 Other Hours.
Participation in an approved high-impact learning practice; reflection on professional outcomes from engineering body of knowledge; documentation and self-assessment of learning experience at mid-curriculum point.
Prerequisite: Junior or senior classification.

MEEN 401 Introduction to Mechanical Engineering Design
Credits 3. 2 Lecture Hours. 3 Lab Hours.
The design innovation process; need definition, functional analysis, performance requirements and evaluation criteria, conceptual design evaluation, down-selected to an embodiment; introduction to systems and concurrent engineering; parametric and risk analysis, failure mode analysis, material selection, and manufacturability; cost and life cycle issues, project management.
Prerequisites: MEEN 360, MEEN 361, MEEN 364, MEEN 368, MEEN 461.

MEEN 402 Intermediate Design
Credits 3. 2 Lecture Hours. 3 Lab Hours.
Product detail design and development process including case studies; project management, marketing considerations, manufacturing, detailed design specifications; failure modes, application of codes and standards, selection of design margins; product (component) development guidelines; intellectual property, product liability and ethical responsibility.
Prerequisites: MEEN 401; junior or senior classification.

MEEN 404 Engineering Laboratory
Credits 3. 2 Lecture Hours. 3 Lab Hours.
Systematic design of experimental investigations; student teams identify topics and develop experiment designs including: establishing the need; functional decomposition; requirements; conducting the experiment; analyzing and interpreting the results and written and oral reports documenting the objectives, procedure, analysis, and results and conclusion of two or three experiments.
Prerequisites: MEEN 260, MEEN 360, MEEN 361, MEEN 364 and MEEN 461; MEEN 401 or registration therein; junior or senior classification.

MEEN 408 Introduction to Robotics
Credits 3. 3 Lecture Hours.
Forward and inverse kinematics of robot manipulators, path planning, motion planning for mobile robots, dynamics of robot manipulators, control algorithms; computed torque algorithm, adaptive control algorithms and current topics in mobile robots; cooperative motion planning of mobile robots and formation control.
Prerequisites: MEEN 364 or equivalent; junior or senior classification.

MEEN 410 Internal Combustion Engines
Credits 3. 3 Lecture Hours.
Thermodynamics of cycles for internal combustion engines and gas turbines, including fuels and combustion; performance characteristics of various types of engines.
Prerequisite: MEEN 344 or equivalent or approval of instructor.

MEEN 411 Mechanical Controls
Credits 3. 3 Lecture Hours.
Application of classical and modern control theory techniques to modeling, analysis and synthesis of linear, mechanical control systems.
Prerequisite: MEEN 364.

MEEN 414 Principles of Turbomachinery
Credits 3. 3 Lecture Hours.
Aero-thermodynamic and mechanical design of turbomachinery components including steam and gas turbine stages, compressor stages, and inlet and exhaust systems, and their integration into power and thrust generation units; design and off-design behaviors of turbine and compressor stages and units; design with SolidWorks.
Prerequisites: MEEN 421 or approval of instructor; junior or senior classification.
MEEN 417/NUEN 417 Basics of Plasma Engineering and Applications
Credits 3. 3 Lecture Hours.
Basic plasma properties and confinement techniques; single particle orbits in electric and magnetic fields, moments of Boltzmann equation and introduction to fluid theory; wave phenomena in plasmas and introduction to plasma kinetic theory; analysis of laboratory plasmas and plasma applications including fusion, electric propulsion, materials processing and plasmas enhanced chemistry.
Prerequisites: PHYS 208 or equivalent; senior classification in nuclear, mechanical or aerospace engineering, physics, or approval of instructor.
Cross Listing: NUEN 417/MEEN 417.
MEEN 421 Thermal-Fluids Analysis and Design
Credits 3. 3 Lecture Hours.
Integration of thermodynamics, fluid mechanics and heat transfer through application to the design of various thermal systems comprised of several components requiring individual analyses; analysis of the entire system; representative applications of thermal-fluids analysis with a design approach.
Prerequisites: MEEN 461; MEEN 315; junior or senior classification.
MEEN 430 Nanomaterials
Credits 3. 3 Lecture Hours.
Fundamentals of nanotechnology, including nanomaterials, types of nanomaterials, fabrication, characterization methods, and applications; explore current roles in technology and future impact on such systems on industry.
Prerequisites: Junior or senior classification and approval of instructor.
MEEN 431 Advanced System Dynamics and Controls
Credits 3. 3 Lecture Hours.
Unified framework for modeling, analysis, synthesis, design and simulation of mechanical systems with energy exchange across multiple domains; study of mechanical, electrical, hydraulic and thermal subsystems; Newtonian mechanics, rigid body dynamics, multiple degrees of freedom vibrations and control system design.
Prerequisites: MEEN 364; junior or senior classification.
MEEN 432 Automotive Engineering
Credits 3. 3 Lecture Hours.
Introduction to vehicle dynamics; application of engineering mechanics principles to analysis of acceleration and braking, cornering and handling; analysis and design of drive train, suspension, brakes, and tires to achieve desired performance.
Prerequisite: MEEN 363.
MEEN 433 Mechatronics
Credits 3. 2 Lecture Hours. 3 Lab Hours.
Basic principles of digital logic and analog circuits in mechanical systems; electrical-mechanical interfacing; sensors and actuators; digital control implementation; precision design and system integration.
Prerequisite: MEEN 364 or equivalent.
MEEN 434 Dynamics and Modeling of Mechatronic System
Credits 3. 3 Lecture Hours.
Mechatronic interactions in lumped parameter and continuum systems; review of integral and differential electromagnetic laws, including motions; lumped elements and dynamic equations of motion; linear and nonlinear actuators and transducers; field transformation and moving media; electromagnetic force densities and stress tensors.
Prerequisite: MEEN 364.
MEEN 436 Principles of Heating, Ventilating and Air Conditioning
Credits 3. 3 Lecture Hours.
Application of thermodynamics fluid mechanics, and heat transfer to the design of HVAC equipment; selection of equipment, piping and duct layouts.
Prerequisite: MEEN 461 or equivalent.
MEEN 437 Principles of Building Energy Analysis
Credits 3. 3 Lecture Hours.
Analysis of building energy use by applying thermodynamics and heat transfer to building heating and cooling load calculations; heat balance and radiant time series calculation methods; psychrometric analysis, indoor air quality, effect of solar radiation on heating and cooling of buildings. Required design project.
Prerequisites: MEEN 315 or equivalent; junior or senior classification.
MEEN 439 Solar Energy Engineering
Credits 3. 3 Lecture Hours.
Solar energy; solar angles and radiation; solar thermal systems; solar water heating and space heating; concentrated solar power; energy storage; solar photovoltaics; solar cell manufacturing; other solar energy technologies.
Prerequisite: MEEN 315.
MEEN 440 Bio-inspired Engineering Design
Credits 3. 3 Lecture Hours.
Expand design space available to engineering by developing and understanding of how nature solves problems; study of effective bio-inspired design and biomimetic applications to draw solutions from nature; enhance concept generation through the use of bio-inspired design; use current state of the art methods in bioinspired design; view nature’s solutions to different problems form an engineering perspective.
Prerequisite: MEEN 368, BMEN 361, or BAEN 375.
MEEN 441 Design of Mechanical Components and Systems
Credits 3. 3 Lecture Hours.
Design of machine elements, characteristics of prime movers, loads and power transmission elements as related to mechanical engineering design.
Prerequisite: MEEN 368 or approval of instructor.
MEEN 442 Computer Aided Engineering
Credits 3. 3 Lecture Hours.
Effective and efficient use of modern computer hardware and software in modeling, design, and manufacturing; simulation of a broad spectrum of mechanical engineering problems.
Prerequisites: MEEN 363 and MEEN 368.
MEEN 444 Finite Element Analysis in Mechanical Engineering
Credits 3. 3 Lecture Hours.
Introduction to basic theory and techniques; one- and two-dimensional formulations for solid mechanics applications; direct and general approaches; broader aspects for field problems; element equations, assembly and solution schemes; computer implementation, programming and projects; error sources and application consideration.
Prerequisites: MEEN 357 and 368 or equivalents.
MEEN 445 Engineering Applications of Solid Mechanics
Credits 3. 3 Lecture Hours.
Mechanical and mathematical basis for modeling response of solid bodies undergoing coupled mechanical and non-mechanical effects, analysis of stress and deformation for structural members subjected to axial, torsional and bending loads, design of multifunctional systems.
Prerequisites: CVEN 305, MEEN 368.
MEEN 451 Viscoelastic Materials
Credits 3. 3 Lecture Hours.
Mechanical and mathematical basis for modeling linear viscoelastic materials which focus on polymeric solid materials; characterization of viscoelastic material properties from experimental tests; applications of stress and deformation relationships for viscoelastic structural members subjected to axial, torsional, and bending loads.
Prerequisites: CVEN 305; junior or senior classification.

MEEN 454 Tribology
Credits 3. 3 Lecture Hours.
History and significance of tribology, rough surfaces, hertzian contact, rough surfaces in contact, friction of surfaces in contact, surface failures/wear, boundary lubrication, fluid properties, thick film lubrication, thin film lubrication, micro- and nano-tribology.
Prerequisites: Grade of C or better in MEEN 344 and MEEN 368.

MEEN 455 Engineering with Plastics
Credits 3. 3 Lecture Hours.
Polymer structure, processing, property characterization at the molecular, microscopic and macroscopic dimensional levels for thermosets, thermoplastics, elastomers, fibers and advanced fibrous nonparticle filled composites and smart multi-performance structures.
Prerequisite: MEEN 222/MSEN 222 or approval of instructor.

MEEN 458 Processing and Characterization of Polymers
Credits 3. 3 Lecture Hours.
Introduction of flow behavior in polymers; structure-property-process relationship; mixing rules for polymer blends; mechanical properties; laboratory demonstrations: injection molding, extrusion, melt mixing, and study of morphology using OM, SEM, and TEM.
Prerequisite: MEEN 222/MSEN 222.

MEEN 459 Sound and Vibration Measurements
Credits 3. 3 Lecture Hours.
Basic acoustics, review of vibration theory, wave propagation in vibrating systems, sound radiation from vibrating systems, sound and vibration sensors and instrumentation, data acquisition systems, measurement techniques, spectral analysis, spatial FFT analysis, design of experiments with vibro-acoustic systems, applications.
Prerequisites: MEEN 363; MATH 308.

MEEN 460 Corrosion Engineering
Credits 3. 3 Lecture Hours.
Basic corrosion phenomena are described, including mixed potential theory, types of corrosion, experimental methods, and prevention techniques.
Prerequisite: MEEN 360 and MEEN 361, or equivalent.

MEEN 461 Heat Transfer
Credits 3. 3 Lecture Hours.
Heat transfer by conduction, convection and radiation: steady and transient conduction, forced and natural convection, and blackbody and gray body radiation; multi-mode heat transfer; boiling and condensation; heat exchangers.
Prerequisites: MEEN 344; MATH 308.

MEEN 463 Cogeneration Systems
Credits 3. 3 Lecture Hours.
Design and analysis of cogeneration system; selection of the prime mover, matching power and thermal needs, institutional factors, economic evaluations, financial options and the study of actual and hypothetical systems.
Prerequisite: MEEN 421 or equivalent.

MEEN 464 Heat Transfer Laboratory
Credit 1. 3 Lab Hours.
Basic measurement techniques in conduction, convection, and radiation heat transfer; experimental verification of theoretical and semi-empirical results; uncertainty analysis.
Prerequisite: MEEN 345, MEEN 461 or registration therein.

MEEN 467 Mechanical Behavior of Materials
Credits 3. 3 Lecture Hours.
Fundamentals of flow and fracture in metals, emphasizing safe design by anticipating response of materials to complex stress and environmental service conditions; micromechanisms of flow, fatigue, creep and fracture; fracture mechanics approach to design. Special emphasis given to microstructure-mechanical property relationship and damage tolerant design.
Prerequisite: MEEN 360 and MEEN 361.

MEEN 469 Alternative Energy Conversion
Credits 3. 3 Lecture Hours.
Design and analysis of alternative energy conversion processes and systems that are based on converting energy directly (e.g., fuel cells, photovoltaics), utilizing non-combustible heat sources (e.g., geothermal, ocean gradients, solar and nuclear fission and fusion) and obtaining energy from the environment (e.g., wind, hydroelectric, ocean tides and waves).
Prerequisite: MEEN 315.

MEEN 471 Elements of Composite Materials
Credits 3. 3 Lecture Hours.
Fundamentals concerned with relating structure of multiphase materials to physical properties; plastic, metallic and ceramic matrices reinforced with continuous and discontinuous fibers, whiskers and particulates.
Prerequisites: MEEN 360, MEEN 361, and MEEN 368 or approval of instructor.

MEEN 472 Gas Dynamics
Credits 3. 3 Lecture Hours.
Fundamental analysis of compressible flows and its application to supersonic airfoils/projectiles, jet and rocket nozzles, normal and oblique shock waves, explosion waves, shock tubes, supersonic wind tunnels, and compressible pipe flows.
Prerequisite: MEEN 344.

MEEN 475 Materials in Design
Credits 3. 3 Lecture Hours.
The heuristics of synthesis of material properties, configuration and processing in the optimization of material selection in the design process; product design and development overview, failure mode effects analysis, design margin establishment; role of the generic failure modes and codes and standards; fundamental characteristics of process methods.
Prerequisites: MEEN 360 and MEEN 361; CVEN 305.

MEEN 476 Nanoscale Issues in Manufacturing
Credits 3. 3 Lecture Hours.
Fundamentals of manufacturing techniques at the nanoscale and larger length scales; design approaches and issues; direct fabrication of nanostructures; nanomanufacturing as a building block to larger objects; fabrication of composites and devices utilizing nanoscale components.
Prerequisites: MEEN 222/MSEN 222 or approval of instructor; junior or senior classification.
MEEN 477 Air Pollution Engineering
Credits 3. 3 Lecture Hours.
Design of air pollution abatement equipment and systems to include cyclones, bag filters, and scrubbers; air pollution regulations; permitting; dispersion modeling; National Ambient Air Quality Standards.
Prerequisite: ENGR 214 or equivalent.
Cross Listing: BAEN 477 and SENG 477.

MEEN 485 Directed Studies
Credits 1 to 6. 1 to 6 Other Hours.
Special problems relating to a specific project in some phase of mechanical engineering. A commitment of two semesters with 6 hours 485 credit is required.
Prerequisites: Approval of department head and senior classification.

MEEN 489 Special Topics in...
Credits 1 to 4. 1 to 4 Other Hours.
Selected topics in an identified area of mechanical engineering.
Prerequisite: Approval of instructor.

MEEN 491 Research
Credits 1 to 4. 1 to 4 Other Hours.
Research conducted under the direction of faculty member in mechanical engineering. May be repeated 2 times for credit. Registration in multiple sections of this course is possible within a given semester provided that the per semester credit hour limit is not exceeded.
Prerequisites: Junior or senior classification and approval of instructor.