

# COURSES FOR MECHANICAL ENGINEERING

## Mechanical Engineering Courses

### ME501 Mech Engr Analysis I

Hours 3

This course is designed to provide the graduate students with fundamental concepts of advanced mathematical analysis of continuous and discrete mechanical engineering systems. The course includes intensive discussion of ordinary differential equations, Fourier analysis, and advanced vector calculus with applications to dynamic systems, heat transfer as well as fluid and solid mechanics.

### ME506 Found Thermal Power Gen

Hours 3

Thermal power systems; components, process analysis and modeling, fuels, combustion, environmental aspects, and availability analysis in steam and gas turbine plants. Examination of recent trends such as cogeneration and combined cycles.

### ME508 Non-Equilibrium Gas Dynamics

Hours 3

This course covers basics of the kinetic theory of gases, methods of solving the problems formulated in terms of the Boltzmann equation, as well as their applications in engineering and technology. The course focuses on the direct simulation Monte Carlo (DSMC) method as the primary practical tool for simulations of non-equilibrium gas flows.

### ME509 Intermed Heat Transfer

Hours 3

A first course in heat transfer at graduate level. Review of undergraduate treatment of conduction, convection, and radiation modes of energy transfer, with emphasis on theoretical concepts. Topics may include separation of variables solutions, superposition concepts, development of boundary layer equations, similarity solutions, spectral dependence of surface radiative properties, radiation exchange in diffuse, gray enclosures.

Prerequisite(s): ME 309 and AEM 311

### ME511 Computational Heat Transfer and Fluid Flow

Hours 3

An introductory course providing computational background and experience to solve realistic heat transfer and fluid flow problems. Course will provide background on numerical techniques, and exposure to computer programming and commercial computational fluid dynamics (CFD) software.

### ME514 Principles of Combustion I

Hours 3

Energy sources, combustion systems, fuels and emissions, combustion thermodynamics, chemical kinetics, 1D reactors, combustion phenomena (ignition, flashback, blow-off, deflagration, detonation, etc.), laminar and turbulent premixed and non-premixed flames, and heterogeneous combustion.

### ME516 Fnd Energy Conserv & Mgt

Hours 3

Analysis and management of energy use in residential, commercial, and industrial applications, including lighting, heating and cooling, controls, and energy management systems. Topics include economics, auditing, energy management, and alternative energy sources.

### ME517 Sustainable Energy

Hours 3

The course is presenting the thermodynamics, heat transfer, and fluid mechanics aspects of renewable energy systems and applications. An overview of common systems and applications for renewable energy sources are provided. Renewable energy systems are described, and their fundamental analyses are discussed. The course provides insight into both the scientific foundations and the engineering practice of renewable energy systems. The course covers both technical and economic analyses of renewable systems. The analysis will be done through practical examples. The general energy picture of the world is presented with an introduction to renewable energy systems and comparison with various fossil fuels. Fundamentals and applications of solar energy systems are analyzed followed by wind, hydro, geothermal, biomass, and ocean energies. Hydrogen is introduced as an energy carrier and the principles of fuel cells are described. The engineering economic analyses of renewable energy projects are also discussed. Finally, environmental effects of energy are covered in this course.

### ME520 Gas Turbines

Hours 3

Build understanding of aviation and industrial gas turbines, their components, design, and performance. The course will also cover improvements being made in the industry to make gas turbines environment friendly and a discussion of future options.

Prerequisite(s): ME 305

### ME522 Reliability Maint & TPM

Hours 3

*No description available*

### ME526 Internal Combustion Engines

Hours 3

This course introduces how internal-combustion engines work, and links analysis and testing techniques used for their design and development to subjects presented within the mechanical engineering curriculum. Laboratory activities serve to reinforce and illustrate analysis application as well as provide visual reference to common internal-combustion engine components.

Prerequisite(s): ME 305

### ME530 Fuzzy Set Theory & Application

Hours 3

The course covers the basic concepts in fuzzy set theory, fuzzy logic, and approximate reasoning. Relation between fuzzy set theory, probability theory, and possibility theory is discussed. Applications of fuzzy set theory in manufacturing systems are outlined. Basic knowledge of probability theory and set theory is expected. Students need to be conversant with calculus and basics of matrix-vector manipulations.

### **ME538 Modeling of Deformation Processes Part I**

Hours 3

Introduction to the finite element method with a special focus on linear elastic deformation modeling with application to solids and structures. This course will cover the mathematical formulation of the strong form, weak form, and finite element solution, along with techniques for the computational implementation of the finite element method. Operational experience with programming (MATLAB or equivalent) is strongly recommended.

Prerequisite(s): MATH 237 or MATH 510 or GES 551 or instructor approval

### **ME540 Failure of Engineering Materials**

Hours 3

Understand how structural components fail and apply the proper techniques for a failure analysis investigation. Demonstrate the ability to identify and differentiate fractographic features of material failure including overload and progressive failures (ductile, brittle, fatigue, creep, corrosion, wear). Practical failure analysis project experience included.

### **ME542 Multiscale Material Design**

Hours 3

This course covers an introduction to materials modeling, terminology, and fundamentals of modeling/simulations in engineering systems, modeling materials at atomic scales using molecular dynamics techniques, statistical methods, mesoscale simulations using phase-field, largescale simulations using continuum mechanics, and finite element method. It also provides basic training on the software tools used in the field – e.g., COMSOL, LAMMPS, VMD, ParaView. Students will learn to develop analytical material models across different scales, build associated numerical codes, perform computer simulations, visualize the data, and analyze the results.

### **ME544 Forming Processes**

Hours 3

This course covers the mechanics of materials in application to forming processes. It includes an introduction to index notation and tensor algebra, the kinematics of motion, stress and strain tensors, constitutive models, balance laws and governing equations, boundary conditions, and an overview of solution methods for material forming processes.

### **ME546 Atomistic Modeling of Materials**

Hours 3

This course focuses on the classical molecular dynamics method as a universal tool for calculation of properties of matter in solid, liquid, and gaseous states. The course includes both lectures and a computer practicum that requires elementary programming in C and use of the LAMMPS molecular simulator. An introduction into C programming is provided as a part of the course.

Prerequisite(s): ME 501

### **ME548 Biomechanics of Human Movement**

Hours 3

An overview of the broad field and major challenges of movement bio mechanics; II. the principles of classical mechanics, anatomy, and physiology to describe, analyze, and assess human motion; and III. the engineering tools and the mathematical approaches applied to perform bio mechanical analysis of moving bodies.

### **ME550 Advanced Machine Design**

Hours 3

The theory and application of creep, high temperature fatigue, fretting fatigue, contact mechanics, and fracture mechanics to design against catastrophic failures in structures are studied.

Prerequisite(s): ME 350

### **ME552 Fundamentals of Automotive Systems**

Hours 3

Description of a generic vehicle development process. Full vehicle concepts. Performance and fuel efficiency calculations. Fundamentals of internal combustion engines, thermodynamic principles, vibrations. Transmission and drive train design.

Prerequisite(s): MATH 238 Differential equations.

### **ME556 Mechatronics**

Hours 3

This is the introductory course to the field of Mechatronics and Robotics. It covers fundamentals of electronics required for mechatronics systems, introduction to microcontroller (Arduino/Beaglebone/Raspberry pi) programming and interfacing, data acquisition, sensing and actuation. The course is a mix of instructional theory and lab, coupled with an independent exploratory project.

### **ME558 Modeling and Simulation of Automotive Systems**

Hours 3

Introduction to modeling and simulation of automotive systems with various components including internal combustion engine, transmission, battery, electric motor, and chassis dynamics. Energy efficiency and dynamic performances of conventional, hybrid electric, and full electric vehicles are covered.

Prerequisite(s): ME 349: Engineering Analysis ME 372: Dynamic Systems

### **ME560 Thermal Fluid Measurement and Analysis**

Hours 3

Methods for acquisition and analysis of thermal systems-based measurements and actuator controls. Practical applications of various programming interfaces and embedded devices. Assignments focus on thermal-fluid measurement/actuator control topics applied to student's research topics. Assignment and lecture material will be supported by benchtop demonstrations of sensors and actuators in-class as appropriate.

### **ME562 Intermediate Dynamics**

Hours 3

Dynamics of systems in moving coordinate frames; Lagrangian formulation and Hamilton's principle; stability and perturbation concepts for rigid body motion; motion of systems of rigid bodies in three dimensions.

### **ME564 Additive Manufacturing of Metals by Design**

Hours 3

This course delves into the world of design of components and processes to be built using Additive Manufacturing techniques. Students explore design principles, advanced techniques, and material selection for crafting intricate metal components. The course empowers participants to harness cutting edge technologies in metal fabrication, fostering creativity and expertise in the field.

**ME570 Mechanical Vibrations**

Hours 3

Formulation and solution of free and forced vibration problems for undamped and damped systems with single and multiple degrees of freedom. An introduction to modeling vibrations in continuous systems is also included. Superposition methods utilizing waveform decomposition, such as Fourier Series, are presented for use in both solution methods and system analysis. Experimental techniques of vibration measurement are also introduced.

**ME571 Fundamentals Of Acoustics**

Hours 3

Fundamental physical principles underlying wave propagation and resonance in mechanical systems. The course introduces modeling, applications, and provides experience in acoustic and audio measurements and the associated instrumentation. The human auditory transduction mechanism is also studied along with physical parameters that describe how humans hear.

**ME572 Introduction to Robotic Kinematics**

Hours 3

This course covers the fundamental concepts of robotics that will enable students to perform kinematic and static force analyses of robotic systems. Rigid-body motion in three-dimensional space is analyzed using rotation and transformation matrices. Screw theory approach is used for representing and conducting forward kinematics of manipulators (product of exponentials). Inverse kinematics of open-chain manipulators is examined using analytical and numerical techniques. Jacobian-based methods are discussed for conducting velocity and static force analyses.

**ME575 Control Systems Analysis**

Hours 3

Classical feedback control system analysis, Laplace transform, transfer function, time response, proportional-integral-derivative control, root locus, frequency response, and computerized analysis. Also includes a brief introduction to modern control techniques.

**ME577 Advanced Linear Control**

Hours 3

Modern techniques for the analysis and design of linear control systems. Matrix formulation; multivariable control systems; state-variable concepts; discrete-time systems; optimization; and statistical design methods.

**ME583 Additive Manufacturing**

Hours 3

Introduction to Additive Manufacturing (AM) and Rapid Prototyping. This course will cover the various techniques for AM such as Liquid AM, Sheet AM, Wire AM, and Powder AM. Students will compare physical and mechanical properties of additively manufactured parts and explore a broad range of 3D-Printing applications including biomedical, aerospace, army, and consumer products.

**ME585 Microfabrication**

Hours 3

Microelectromechanical Systems (MEMS) are miniature devices comprising of integrated mechanical (levers, springs, deformable membranes, vibrating structures, etc.) and electrical (resistors, capacitors, inductors, etc.) components designed to work in concert to sense and report on the physical properties of their immediate or local environment, or, when signaled to do so, to perform controlled physical interaction or actuation with their immediate or local environment. Microfabrication technology is the science behind this miniaturization. Most microfabrication techniques have similar roots to those developed originally for the fabrication of integrated circuits. MEMS and Microfabrication cut across a large number of industries and applications, which is part of why their potential is so compelling. Lightweight computers, cellular phones, digital cameras, microneedles for painless drug deliveries, airbag sensors, etc. would not be here without advancements in MEMS and microfabrication technology. This course brings together the basic understanding of various microfabrication processes, different MEMS devices, and how they can be exploited in a wide range of engineering applications. The physics behind the operation of different fabrication tools will be covered, and the fabrication and operation of real-world examples will be explained.

**ME591 Special Problems**

SP

Hours 3

This course covers topics not currently covered by an existing course in the catalog and is usually associated with a faculty member's specialty area. Content varies by section and semester.

Special Topics Course

**ME594 Special Project**

SP

Hours 2-6

Planning, executing, and presenting results of an individual project involving a research design, analysis, or similar undertaking.

Special Topics Course

**ME598 Non-Thesis Research**

Hours 1-3

*No description available*

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**ME599 Thesis Research**

Hours 1-12

This independent research course partially fulfills required master's-level research thesis hours toward the master's degree in Mechanical Engineering. The course is conducted under the guidance of the thesis advisor. Material covered will be of an advanced nature aimed at providing master's students with an understanding of the latest research and current developments within the field. Discussion and advisor guidance will be directed towards readings of research articles and development of research methodology, with the aim of producing an original research contribution that represents a novel development in the field, or a novel perspective on a pre-existing topic in the field. Variable hours.

**ME605 Classical Thermodynamics**

Hours 3

Classical macroscopic thermodynamic analysis of systems, pure substances, mixtures, and reacting systems.

**ME607 Conduction Heat Transfer**

Hours 3

Transient, multidimensional heat conduction in various geometries, and the mathematical and numerical means to analyze them.

**ME618 Princ Of Combustion II**

Hours 3

Parameters of confined combustion; evaporation of fuel, velocity of flames, detonation, and chamber design; dynamic effects; and measuring techniques. Assigned papers.

**ME638 Modeling of Deformation Processes Part 2**

Hours 3

Introduction to topics regarding non-linear finite element modeling. This course will cover the deformation modeling of solids and structures where the problem exhibits non-linear behavior, with a special focus on non-linear elasticity, plasticity, and the iterative solution methods necessary to solve such problems. Operational experience with programming (MATLAB or equivalent) is strongly recommended.

Prerequisite(s): ME 538

**ME670 Advanced Vibrations**

Hours 3

Covers advanced concepts in mechanical vibration analysis. Topics include introduction to variational approach and energy methods applied to motions of deformable body in three dimensions; vibrations of distributed-parameters systems including strings, bars, shafts, beams, membranes, and plates. Covers approximate methods, Rayleigh's Quotient, Rayleigh-Ritz method, method of functions expansion, Galerkin's and assumed mode methods, design and analysis of a variety of vibration-control systems, and recent advances in vibration of micro- and nano-scale systems.

Prerequisite(s): ME 470 or ME 570

**ME674 Nonlinear Control Systems**

Hours 3

Analysis of nonlinear systems. Nonlinear controller design techniques. State variables, phase plane analysis, describing functions, and Lyapunov stability theory.

Prerequisite(s): ME 475 OR ECE 475

**ME691 Special Problems**

SP

Hours 1-6

*No description available*

Special Topics Course

**ME694 Special Project**

SP

Hours 2-6

Planning, executing, and presenting results of an individual project involving a research design, analysis, or similar undertaking.

Special Topics Course

**ME695 Graduate Seminar**

Hours 1

This is a first course in Graduate Research Seminar series offered by the Department of Mechanical Engineering. Students are exposed to a variety of lectures.

**ME696 Graduate Seminar**

Hours 1

This is a second course in Graduate Research Seminar series offered by the Department of Mechanical Engineering. Students are exposed to a variety of lectures.

Prerequisite(s): ME 695

**ME697 Graduate Seminar**

Hours 1

This is a third course in Graduate Research Seminar series offered by the Department of Mechanical Engineering. Students are exposed to a variety of lectures.

Prerequisite(s): ME 695 and ME 696

**ME698 Non-Dissertation Research**

Hours 1-12

Credit is based on the amount of work undertaken on non-dissertation related research in a mechanical engineering area, the outcome of which is a defined result presented in a report, paper, manuscript, or presentation at a conference or seminar. Instructor permission required.

**ME699 Dissertation Research**

Hours 1-12

This independent research course partially fulfills required doctoral-level research dissertation hours toward the doctoral degree in Mechanical Engineering. The course is conducted under the guidance of the dissertation advisor. Material covered will be of an advanced nature aimed at providing doctoral students with an understanding of the latest research and current developments within the field. Discussion and advisor guidance will be directed towards readings of research articles and development of research methodology, with the aim of producing an original research contribution that represents a novel development in the field, or a novel perspective on a pre-existing topic in the field.