

MECHANICAL ENGINEERING

Contact Information

Mechanical Engineering

<https://mech.rice.edu/>

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Undergraduate studies in mechanical engineering can lead to careers that focus on a diverse set of areas, including aerospace engineering, biomedical systems, computational fluid dynamics, computational mechanics, fluids-thermal science, mechanical design, mechanics, robotics, systems dynamics and controls.

The graduate program offers professional degrees in mechanical engineering, which permits specialization in the areas previously mentioned. Graduate students also may pursue research degrees.

The graduate program, in its comprehensive educational and research activities, collaborates with other departments at Rice and other institutions in Houston, including those in the Texas Medical Center. Collaborations also are extended to universities in the United States, Europe, Japan, and South America. International collaborations include joint research activities and faculty and student visitor exchanges.

Bachelor's Programs

- Bachelor of Arts (BA) Degree with a Major in Mechanical Engineering (<https://ga.rice.edu/programs-study/departments-programs/engineering/mechanical-engineering/mechanical-engineering-ba/>)
- Bachelor of Science in Mechanical Engineering (BSME) Degree (<https://ga.rice.edu/programs-study/departments-programs/engineering/mechanical-engineering/mechanical-engineering-bsme/>)

Master's Programs

- Master of Mechanical Engineering (MME) Degree (<https://ga.rice.edu/programs-study/departments-programs/engineering/mechanical-engineering/mechanical-engineering-mme/>)
- Master of Science (MS) Degree in the field of Mechanical Engineering (<https://ga.rice.edu/programs-study/departments-programs/engineering/mechanical-engineering/mechanical-engineering-ms/>)

Doctoral Program

- Doctor of Philosophy (PhD) Degree in the field of Mechanical Engineering (<https://ga.rice.edu/programs-study/departments-programs/engineering/mechanical-engineering/mechanical-engineering-phd/>)

Chair

Marcia K. O'Malley

Professors

John Edward Akin

Yildiz Bayazitoglu

Benjamin J. Fregly

Fathi Ghorbel

C. Fred Higgs, III

Marcia K. O'Malley

Laura Schaefer

Pol D. Spanos

Tayfun E. Tezduyar

Associate Professors

Matthew Brake

Peter Lillehoj

Assistant Professors

Pedram Hassanzadeh

Daniel Preston

Geoffrey Wehmeyer

Professor Emeritus

Chao-Cheng Wang

Professor in the Practice

Patrick Rodi

Lecturers

Roberto Dugnani

David Trevas

Professors, Joint Appointments

Reginald DesRoches

Kathryn Jane Grande-Allen

Lydia Kavradi

Satish Nagarajaiah

Adjunct Professors

Aladin Boriek

James Dabney

Thomas J. R. Hughes

Adjunct Associate Professors

Kenji Takizawa

David Woffinden

For Rice University degree-granting programs:

To view the list of official course offerings, please see [Rice's Course Catalog](https://courses.rice.edu/admweb/!SWKSCAT.cat?p_action=cata) (https://courses.rice.edu/admweb/!SWKSCAT.cat?p_action=cata)

To view the most recent semester's course schedule, please see [Rice's Course Schedule](https://courses.rice.edu/admweb/!SWKSCAT.cat) (<https://courses.rice.edu/admweb/!SWKSCAT.cat>)

Mechanical Engineering (MECH)

MECH 200 - CLASSICAL THERMODYNAMICS

Short Title: CLASSICAL THERMODYNAMICS

Department: Mechanical Engineering

Grade Mode: Standard Letter

Course Type: Lecture

Credit Hours: 3

Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.

Course Level: Undergraduate Lower-Level

Prerequisite(s): PHYS 101 or PHYS 111

Description: Explication of the fundamental laws of classical thermodynamics and deductions from them. Includes applications with particular attention to pure substances. Required for mechanical engineering majors. Recommended Prerequisite(s): PHYS 102.

MECH 202 - MECHANICS/STATICS

Short Title: MECHANICS/STATICS

Department: Mechanical Engineering

Grade Mode: Standard Letter

Course Type: Lecture

Credit Hours: 3

Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.

Course Level: Undergraduate Lower-Level

Prerequisite(s): (MATH 101 or MATH 105) and (MATH 102 or MATH 106) and (PHYS 101 or PHYS 111)

Description: Mechanics is the branch of the physical sciences that deals with the response of bodies to the action of forces and is based on the implementation of Newton's laws. This class is divided into two sections: study of rigid bodies in equilibrium; and strength of materials. Fundamental concepts such as equilibrium, stress and strain, deformations and displacements, elasticity and inelasticity, strain energy, and load-carrying capacity will be covered.

MECH 203 - MECHANICAL ENGINEERING DESIGN TOOLS

Short Title: MECH ENG DESIGN TOOLS

Department: Mechanical Engineering

Grade Mode: Standard Letter

Course Type: Lecture/Laboratory

Credit Hours: 3

Restrictions: Enrollment is limited to students with a major in Mechanical Engineering. Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.

Course Level: Undergraduate Lower-Level

Prerequisite(s): PHYS 101 or PHYS 111

Description: Learning the use of computer aided design tools for preparing complex solid parts, assemblies, and their dimensioned drawings. Learn to apply black-box simulation tools for stress analysis, heat transfer, vibration, etc. of complex parts and assemblies.

MECH 210 - INTRODUCTION TO NUMERICAL METHODS

Short Title: INTRO TO NUMERICAL METHODS

Department: Mechanical Engineering

Grade Mode: Standard Letter

Course Type: Lecture

Credit Hours: 3

Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.

Course Level: Undergraduate Lower-Level

Prerequisite(s): PHYS 101 and PHYS 102 and (MATH 101 or MATH 105) and (MATH 102 or MATH 106)

Description: Numerical Methods covers computational methods for generating numerical solutions to mathematical problems, with an emphasis on engineering applications and computer implementation in MATLAB.

MECH 211 - ENGINEERING MECHANICS

Short Title: ENGINEERING MECHANICS

Department: Mechanical Engineering

Grade Mode: Standard Letter

Course Type: Lecture

Credit Hours: 3

Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.

Course Level: Undergraduate Lower-Level

Prerequisite(s): (PHYS 101 or PHYS 111 or PHYS 125 or PHYS 141) and (MATH 101 or MATH 105) and (MATH 102 or MATH 106)

Description: The study equilibrium of static systems, the dynamics of a particle and particle systems, and rigid-body dynamics. Cross-list: CEVE 211.

MECH 231 - SOPHOMORE LAB

Short Title: SOPHOMORE LAB

Department: Mechanical Engineering

Grade Mode: Standard Letter

Course Type: Laboratory

Credit Hour: 1

Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.

Course Level: Undergraduate Lower-Level

Prerequisite(s): MECH 200 (may be taken concurrently)

Description: Instruction in application of engineering thermodynamics. Includes uncertainty analysis, measurement of thermodynamic properties, and design of experiments. Required for mechanical engineering majors in B.S. program.

MECH 238 - SPECIAL TOPICS

Short Title: SPECIAL TOPICS

Department: Mechanical Engineering

Grade Mode: Standard Letter

Course Type: Internship/Practicum, Laboratory, Lecture, Seminar, Independent Study

Credit Hours: 1-4

Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.

Course Level: Undergraduate Lower-Level

Description: Topics and credit hours may vary each semester. Contact department for current semester's topic(s). Repeatable for Credit.

MECH 308 - SENIOR DESIGN JUNIOR OBSERVERS**Short Title:** SENIOR DESIGN JUNIOR OBSERVERS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Independent Study**Credit Hour:** 1**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Description:** Repeatable for Credit.**MECH 310 - RIGID BODY DYNAMICS****Short Title:** RIGID BODY DYNAMICS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Prerequisite(s):** (PHYS 101 or PHYS 111) and (MATH 101 or MATH 105) and (MATH 102 or MATH 106) and MECH 202**Description:** Mechanics is the branch of the physical sciences that deals with the response of bodies to the action of forces and is based on the implementation of Newton's laws. Statics is the study of bodies in equilibrium and is based on Newton's first and third laws, while Dynamics focuses on bodies in motion and is based on Newton's second and third laws. This class focuses on Rigid Body Dynamics.**MECH 311 - MECHANICS OF SOLIDS AND STRUCTURES****Short Title:** MECHANICS OF SOLIDS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to students with a major in Bioengineering, Civil & Environmental Engineer, Civil Engineering or Mechanical Engineering. Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Prerequisite(s):** CEVE 211 or MECH 211**Description:** Analysis of stress and the deformation of solids with applications to beams, circular shafts, and columns. Required for following undergraduate majors: civil and environmental engineering. Cross-list: CEVE 311.**MECH 315 - STRESS ANALYSIS****Short Title:** STRESS ANALYSIS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Prerequisite(s):** MECH 202 or MECH 211**Description:** Stress analysis is integral to much of mechanical engineering, whether in industrial design or academic research. This course is divided into two parts. First, the concepts of stress analysis are introduced for two-dimensional, then three-dimensional bodies. The second part of this course builds upon stress analysis by going into failure – both dynamic and static theories. A series of month long design projects will apply the tools learned in this course to specific engineering problems.**MECH 331 - JUNIOR LABORATORY I****Short Title:** JUNIOR LABORATORY I**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Laboratory**Credit Hour:** 1**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Description:** Instruction in static and impact testing of engineering materials. Includes beam deflection and shear center experiments, as well as the application and testing of strain gauges. Required for mechanical engineering majors in B.S. program.**MECH 332 - JUNIOR LABORATORY II****Short Title:** JUNIOR LABORATORY II**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Laboratory**Credit Hour:** 1**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Corequisite:** MECH 371**Description:** Instruction in fluid mechanics and thermodynamics. Students work in groups and perform classic experiments in fluid flow. This laboratory course provides experimental support to MECH 371. Required course for mechanical engineering majors in B.S. program. See on-line registration for sections.

MECH 340 - INDUSTRIAL PROCESS LAB**Short Title:** INDUSTRIAL PROCESS LAB**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Laboratory**Credit Hour:** 1**Restrictions:** Enrollment is limited to students with a major in Mechanical Engineering. Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Description:** Practical experience in, and observation of, selected industrial processes. Must sign up in department office at the beginning of registration for sections; each section is limited to 8 students. Open only to mechanical engineering majors. Required for mechanical engineering majors in B.S. program. Final registration confirmed after the first week's organizational meeting. Meeting announcements posted in the MEMS department.**MECH 343 - MODELING OF DYNAMIC SYSTEMS****Short Title:** MODELING OF DYNAMIC SYSTEMS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 4**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Prerequisite(s):** (MECH 211 or CEVE 211 or MECH 310) and MECH 200 and MATH 211 and (CAAM 335 (may be taken concurrently) or CMOR 302 (may be taken concurrently))**Description:** Energy-based modeling of dynamic systems. The focus of the course will be mechanical systems and electrical circuits, but will also involve fluid, thermal and other domains. The course will introduce modeling and simulation of systems via MATLAB, Simulink, and Labview, and an introduction to systems theory. Modeling and simulation of systems via MATLAB, and an introduction to systems theory. Includes laboratory assignments. Required for mechanical engineering majors in B.S. program. Note: Prerequisite, CMOR 302 may be taken concurrently.**MECH 350 - MECHANICAL ELEMENTS****Short Title:** MECHANICAL ELEMENTS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Prerequisite(s):** MECH 315**Description:** The principles of mechanics are applied to the design of machine elements, including load path and stress analysis, selection of mechanical components, and materials selection. A semester design project requires using the analysis tools learned in the course. Required for mechanical engineering majors in B.S. program.**MECH 371 - FLUID MECHANICS I****Short Title:** FLUID MECHANICS I**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Prerequisite(s):** MECH 200 and MATH 212**Description:** Introduction to fluid statics and dynamics. Includes the development of the fundamental equations of fluid mechanics and their application to problems of engineering interest. Required for mechanical engineering majors in B.S. program. Department Permission Required.**MECH 373 - ACOUSTICS****Short Title:** ACOUSTICS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Description:** Basics of technical acoustics, including generation, propagation, reception and reproduction of sound, speech and hearing, musical and architectural acoustics, and noise control. Offered alternate years.**MECH 380 - INTRODUCTION TO MECHANICAL EFFECTS IN TISSUES****Short Title:** INTRO TO MECHANICAL EFFECTS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Prerequisite(s):** MECH 211 and MECH 311 or CEVE 300**Description:** Development of a general background in physiology and in advanced mechanics for applications in medicine. Includes bone mechanics in remodeling, cartilage and ligament mechanics, and muscle mechanics, as well as an on paper design project on a subject selected by students.

MECH 383 - INTRODUCTION TO BIOMEDICAL INSTRUMENTATION AND MEASUREMENT TECHNIQUES**Short Title:** BIOMED INSTRUMENT&MESURE TECHN**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Prerequisite(s):** ELEC 381**Description:** Review of basic sensors, measurement principles and analog electronics using operational amplifiers. Includes design problems using operational amplifier circuits (e.g. instrumentation and isolation amplifiers, comparators, timer circuits). Introduction to development of virtual instruments (VIs) using LabView. Discussion of micro and macro-biopotential electrodes, cell cytometry, the measurement of blood pressure, blood flow, and heart sounds, temperature, and the principles of electrical safety (e.g. micro and macro-shock hazards in the clinical environment). Includes discussion of pulmonary instrumentation and medical applications of ultrasound. Two lab exercises and a term project required.**MECH 390 - TOPICAL ISSUES IN ENGINEERING****Short Title:** TOPICAL ISSUES IN ENG**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Seminar**Credit Hour:** 1**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Description:** This discussion based class will focus on current events and how engineering can be used to directly address them throughout a career. Topics will include energy, environmental, space, and societal (e.g., inequality, social media, etc.) related issues amongst others.**MECH 400 - ADVANCED MECHANICS OF MATERIALS****Short Title:** ADV MECHANICS OF MATERIALS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Prerequisite(s):** (MECH 202 or MECH 211 or CEVE 211) and (MECH 311 or MECH 315 or CEVE 311)**Description:** Advanced topics in materials mechanics, including elasticity, plasticity, and brittle and ductile fracture mechanics. A major focus of this course is to approach these advanced mechanics topics from a material perspective. Cross-list: CEVE 400. Graduate/Undergraduate Equivalency: MECH 500. Mutually Exclusive: Cannot register for MECH 400 if student has credit for MECH 500.**MECH 401 - MECHANICAL DESIGN APPLICATIONS****Short Title:** MECHANICAL DESIGN APPLICATIONS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Prerequisite(s):** MECH 311 or CEVE 311**Description:** Brief review of solid mechanics with introduction to failure theories and fatigue analysis. The principles of mechanics are applied to the design of machine elements. A semester design project requires using the analysis tools learned in the course. Required for mechanical engineering majors in B.S. program.**MECH 403 - COMPUTER AIDED DESIGN****Short Title:** COMPUTER AIDED DESIGN**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture/Laboratory**Credit Hours:** 3**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Description:** Investigation of the integration of the computer into the area of mechanical design. Includes such subjects as optimization, finite element, analysis, and commercial software. Graduate/Undergraduate Equivalency: MECH 503. Mutually Exclusive: Cannot register for MECH 403 if student has credit for MECH 503.**MECH 404 - MECHANICAL DESIGN PROJECT****Short Title:** MECHANICAL DESIGN PROJECT**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture/Laboratory**Credit Hours:** 1-4**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Description:** Project based course for group or individual design projects relating to mechanical engineering topics. Instructor Permission Required.**MECH 407 - CAPSTONE DESIGN PROJECT I****Short Title:** CAPSTONE DESIGN PROJECT I**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture/Laboratory**Credit Hours:** 4**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Prerequisite(s):** MECH 343 and (MECH 350 or MECH 401) and MECH 481**Description:** An interdisciplinary capstone design experience in mechanical engineering. This course provides an opportunity for students to apply knowledge and skills acquired in previous courses to the solution of a realistic engineering problem. Teams of students will specify, design, and build a system to meet a prescribed set of requirements. The topics covered in this course will include design methodology, effective teamwork, project management, documentation, and presentation skills. Must complete MECH 408 to receive credit for MECH 407. Required for mechanical engineering majors in B.S. program.

MECH 408 - CAPSTONE DESIGN PROJECT II**Short Title:** CAPSTONE DESIGN PROJECT II**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture/Laboratory**Credit Hours:** 3**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level

Description: An interdisciplinary capstone design experience in mechanical engineering. This course provides an opportunity for students to apply knowledge and skills acquired in previous courses to the solution of a realistic engineering problem. Teams of students will specify, design, and build a system to meet a prescribed set of requirements. The topics covered in this course will include design methodology, effective teamwork, project management, documentation, and presentation skills. Must complete MECH 408 to receive credit for MECH 407. Required for mechanical engineering majors in B.S. program. Department Permission Required.

MECH 411 - DYNAMICS AND CONTROL OF MECHANICAL SYSTEMS**Short Title:** DYNAMICS & CONTROL OF MECH SYS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Prerequisite(s):** MECH 343 and MECH 420

Description: The application of the principles of kinematics, dynamics and systems and control theory to the design and analysis of controlled mechanical systems. Kinematics and Newtonian dynamics of particles and rigid bodies, elements of analytical dynamics, system analysis, stability, and simulation of dynamical behavior, control of mechanical systems. Demonstrations and laboratory examples. Graduate/Undergraduate Equivalency: MECH 501. Mutually Exclusive: Cannot register for MECH 411 if student has credit for MECH 501.

MECH 412 - VIBRATIONS**Short Title:** VIBRATIONS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Prerequisite(s):** MECH 343

Description: Analysis of discrete and continuous linear vibrating systems, with emphasis on multi-degree-of-freedom systems. Includes approximate methods. Coverage of statistics (e.g. Gaussian and other distributions; and power spectra) as a foundation for random vibrations analysis. Required for mechanical engineering majors in B.S. program. Graduate/Undergraduate Equivalency: MECH 502. Mutually Exclusive: Cannot register for MECH 412 if student has credit for MECH 502.

MECH 416 - ADVANCED MACHINE DESIGN AND MECHANICAL SYSTEMS**Short Title:** MACHINES AND MECHANISMS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture/Laboratory**Credit Hours:** 3**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Prerequisite(s):** MECH 350

Description: Continuation of topics covered in a standard undergraduate machine design course, as well as an introduction to mechanical systems commonly used in industry and research. Topics to include mechanical fasteners, weldment design, advanced gearing systems, friction and energy storage devices, and fluid power systems.

MECH 417 - FINITE ELEMENT ANALYSIS**Short Title:** FINITE ELEMENT ANALYSIS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Prerequisite(s):** (MATH 212 or MATH 222) and (CAAM 210 or CAAM 211 or CMOR 220)

Description: An introduction to finite element analysis by Galerkin's method and the method of least squares as applied to both ordinary and partial differential equations common in engineering applications. Element interpolations, numerical integration, computational considerations for efficient solution and post-processing methods. Application of the commercial codes to ANSYS and Cosmosworks. Cross-list: CEVE 417. Graduate/Undergraduate Equivalency: MECH 517. Mutually Exclusive: Cannot register for MECH 417 if student has credit for MECH 517.

MECH 420 - FUNDAMENTALS OF CONTROL SYSTEMS**Short Title:** FUNDAMENTALS OF CONTROL SYST**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Prerequisite(s):** (CAAM 335 or CMOR 302 and MECH 343) or (MATH 355 and MECH 343) or (CAAM 335 or CMOR 302 and ELEC 242 and ELEC 244) or (MATH 355 and ELEC 242 and ELEC 244)

Description: Linear systems and the fundamental principles of classical feedback control, state variable analysis of linear dynamic systems, stability of linear control systems, time-domain analysis and control of linear systems, root-locus analysis and design and pole-zero synthesis, frequency domain techniques for the analysis and design of control systems. Required for mechanical engineering majors in B.S. program. Cross-list: ELEC 436. Graduate/Undergraduate Equivalency: MECH 620. Mutually Exclusive: Cannot register for MECH 420 if student has credit for MECH 620.

MECH 427 - PHYSICS GUIDED MACHINE LEARNING & DATA DRIVEN MODELING FEM**Short Title:** PHY GUIDED ML-DATA DRIVEN FEM**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Prerequisite(s):** CEVE 311 or MECH 311 or MECH 315**Description:** Introduction to physics guided machine learning and data driven modeling from a rigorous finite element analysis and system dynamics (& optimization) perspective. Programming needed will be introduced in the course. The course involves series of assignments involving programming. Project work will be assigned at the end of the semester in lieu of the final exam. Cannot be taken concurrently with CEVE/MECH 527. Prerequisites CEVE/MECH 311. Cross-list: CEVE 427. Mutually Exclusive: Cannot register for MECH 427 if student has credit for MECH 527.**Course URL:** Satishnagarajaiah.rice.edu (<http://Satishnagarajaiah.rice.edu>)**MECH 430 - TRIBOMECHADYNAMICS****Short Title:** TRIBOMECHADYNAMICS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Prerequisite(s):** MECH 315 and MECH 343**Description:** Tribomechadynamics is a graduate/upper level undergraduate course that spans the topics of tribology, contact mechanics, and nonlinear dynamics. These three topics are integral to understanding interfacial contact, how assembled structures behave, and how the evolution of damage (wear) over time at the micro-scale influences the structural-scale response of a system. In brief, the subjects covered by this course are: • Tribology. Topics will include empirical and heuristic friction models, the fundamentals of wear, lubrication selection and considerations, and fundamental failure modes. • Contact Mechanics. Topics will include elastic deformation, constitutive modeling, plasticity, failure criteria, and numerical simulation. • Nonlinear Dynamics. Topics will include an overview of linear vibration theory, model reduction theories, nonlinear vibration theory, nonlinear analysis including quasi-static analysis and harmonic balance methods, continuation, and modal analysis. Graduate/Undergraduate Equivalency: MECH 530.**MECH 431 - SENIOR LABORATORY I****Short Title:** SENIOR LABORATORY I**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Laboratory**Credit Hour:** 1**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Description:** Laboratory instruction in heat transfer and thermodynamics. Students work in groups doing experiments with emphasis on applied thermodynamics. Required for mechanical engineering majors in B.S. program. See online registration for sections.**MECH 444 - FLUID MECHANICS OF COMPUTING****Short Title:** FLUID MECHANICS OF COMPUTING**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Description:** The objective is to learn and develop a good understanding of the fluid mechanics concepts and tools that are essential to know for successful computational flow analysis. For successful computational flow analysis, we first have to know the problem we want to solve, set up the computational conditions correctly, have a good idea about what results to expect, and properly interpret and evaluate the computed results. This course will help us learn the fluid mechanics concepts and tools required for that. The course will have both an easy to follow mathematical approach and an easy to relate to physical-interpretation approach. The topics covered include the basic mathematical framework, key fluid mechanics mechanisms, scaling and nondimensional variables and equations, and simple fluid mechanics formulas that can be used in obtaining analytical estimates to the problems solved. Graduate/Undergraduate Equivalency: MECH 544. Recommended Prerequisite(s): MECH 200 and MATH 212 Mutually Exclusive: Cannot register for MECH 444 if student has credit for MECH 544.**MECH 450 - ALGORITHMIC ROBOTICS****Short Title:** ALGORITHMIC ROBOTICS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 4**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Prerequisite(s):** COMP 321 and COMP 215**Description:** Robots have fascinated people for generations. Today, robots are built for applications as diverse as exploring remote planets, de-mining war zones, cleaning toxic waste, assembling cars, inspecting pipes in industrial plants and mowing lawns. Robots are also interacting with humans in a variety of ways: robots are museum guides, robots assist surgeon in life threatening operations, and robotic cars can drive us around. The field of robotics studies not only the design of new mechanisms but also the development of artificial intelligence frameworks to make these mechanism useful in the physical world, integrating computer science, engineering, mathematics and more recently biology and sociology, in a unique way. This class will present fundamental algorithmic advances that enable today's robots to move in real environments and plan their actions. It will also explore fundamentals of the field of Artificial Intelligence through the prism of robotics. The class involves a significant programming project. Cross-list: COMP 450, ELEC 450. Graduate/Undergraduate Equivalency: MECH 550. Mutually Exclusive: Cannot register for MECH 450 if student has credit for MECH 550.

MECH 454 - COMPUTATIONAL FLUID MECHANICS**Short Title:** COMPUTATIONAL FLUID MECHANICS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Prerequisite(s):** MECH 371 (may be taken concurrently) or MECH 444 (may be taken concurrently) or CEVE 363 (may be taken concurrently) or CHBE 401 (may be taken concurrently) or BIOE 420 (may be taken concurrently) or CHBE 420 (may be taken concurrently)**Description:** Fundamental concepts of finite element methods in fluid mechanics, including spatial discretization and numerical integration in multidimensions, time-integration, and solution of nonlinear ordinary differential equation systems. Advanced numerical stabilization techniques designed for fluid mechanics problems. Strategies for solution of complex, real-world problems. Topics in large-scale computing, parallel processing, and visualization. Prerequisites may be taken concurrently. Cross-list: BIOE 454, CEVE 454. Graduate/Undergraduate Equivalency: MECH 554. Mutually Exclusive: Cannot register for MECH 454 if student has credit for MECH 554.**MECH 466 - SYSTEM IDENTIFICATION OF DYNAMIC SYSTEMS WITH MACHINE LEARNING****Short Title:** SYSTEM I.D. & MACHINE LEARNING**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture/Laboratory**Credit Hours:** 3**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Prerequisite(s):** CEVE 311 or MECH 311 or MECH 315**Description:** Introduction to modeling and system identification of dynamic systems with machine learning. Students in CEVE 596/ MECH 566 will be required to do more advanced assignments and a project. Cross-list: CEVE 496. Graduate/Undergraduate Equivalency: MECH 566.**MECH 472 - THERMAL SYSTEMS DESIGN****Short Title:** THERMAL DESIGN**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Prerequisite(s):** MECH 371 (may be taken concurrently) and MECH 481**Description:** Design and synthesis of systems based on applications of thermodynamics, fluid mechanics, heat transfer, economics, and optimization theories. Required for mechanical engineering majors in B.S. program.**MECH 473 - ADVANCED FLUID MECHANICS I****Short Title:** ADVANCED FLUID MECHANICS I**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Description:** Governing equations for inviscid and viscous flows. Constitutive laws, simple non-Newtonian flows, and surface tension. Derivation and applications of the equations representing the conservation of mass and momentum. Various forms of the Bernoulli equation. Introductory concepts of computational fluid mechanics. Graduate/Undergraduate Equivalency: MECH 573. Mutually Exclusive: Cannot register for MECH 473 if student has credit for MECH 573.**MECH 474 - ADVANCED COMPUTATIONAL MECHANICS****Short Title:** ADV COMPUTATIONAL MECHANICS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Prerequisite(s):** BIOE 454 or CEVE 454 or MECH 454 or BIOE 554 or CEVE 554 or MECH 554**Description:** Undergraduate version of MECH 654. The required semester-end report and presentation will be on the introductory topics of the course. Graduate/Undergraduate Equivalency: MECH 654. Mutually Exclusive: Cannot register for MECH 474 if student has credit for MECH 654.**MECH 477 - SPECIAL TOPICS****Short Title:** SPECIAL TOPICS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Internship/Practicum, Laboratory, Lecture, Seminar, Lecture/Laboratory**Credit Hours:** 1-4**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Description:** Topics and credit hours may vary each semester. Contact department for current semester's topic(s). Repeatable for Credit.**MECH 481 - HEAT TRANSFER****Short Title:** HEAT TRANSFER**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Prerequisite(s):** (MECH 200 and MECH 371)**Description:** Study of the general principles of heat transfer by conduction, convection, and radiation. Includes their application to problems of engineering practice. Required for mechanical engineering majors in B.S. program.

MECH 482 - CONVECTIVE HEAT TRANSFER**Short Title:** CONVECTIVE HEAT TRANSFER**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Prerequisite(s):** MECH 481**Description:** Rigorous study of the transfer of heat by free and forced convection. Graduate/Undergraduate Equivalency: MECH 582. Mutually Exclusive: Cannot register for MECH 482 if student has credit for MECH 582.**MECH 484 - MICROSCOPIC THERMODYNAMICS AND TRANSPORT****Short Title:** MICRO THERMO & TRANSPORT**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Prerequisite(s):** MECH 481**Description:** This course introduces concepts in statistical mechanics and non-equilibrium thermodynamics that are used to understand the physical mechanisms of heat transfer, particularly in micro/nanoscale systems. Emphasis is placed on energy storage and thermal transport by electrons, phonons, molecules, and photons. Topics include the kinetic theory of gases, thermodynamic distribution functions, energy carrier dispersion relations, Boltzmann equation modeling of thermal and electrical properties, size effects (classical and quantum-mechanical) on material properties, and thermoelectric energy conversion. Graduate/Undergraduate Equivalency: MECH 584.**MECH 487 - INTERFACIAL PHENOMENA, CAPILLARITY, AND WETTING****Short Title:** CAPILLARITY AND WETTING**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Description:** This course will provide the fundamental knowledge required for students to analyze, model, and design systems based on interfacial phenomena, with applications including wetting, enhanced oil recovery, cosmetics, pharmaceuticals, microfluidic devices, phase change heat transfer, and even everyday food and drink. After completing this course, students will exhibit a strong understanding of surface tension and surface energy, adsorption and adhesion, surface-tension-driven flows, capillarity, capillary instabilities, contact angle, fluid spreading, wetting of textured surfaces leading to superhydrophobicity and superhydrophilicity, and self-cleaning surfaces. Graduate/Undergraduate Equivalency: MECH 587. Recommended Prerequisite(s): MECH 200 (or equivalent) and MECH 371 (or equivalent) Mutually Exclusive: Cannot register for MECH 487 if student has credit for MECH 587.**MECH 488 - DESIGN OF MECHATRONIC SYSTEMS****Short Title:** DESIGN OF MECHATRONIC SYSTEMS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Prerequisite(s):** MECH 343 or ELEC 241 or ELEC 243**Description:** Analog electronic design for purposes of controlling electromechanical systems, including electromechanical sensors and actuators, analog electronic design of filters, state space and classical controllers, and transistor-based servo amplifiers and high voltage amplifiers. Implementation of digital controllers. Significant laboratory component with design and fabrication of circuits to control electromechanical systems. Graduate/Undergraduate Equivalency: MECH 588. Recommended Prerequisite(s): MECH 310 and ELEC 436 or MECH 420. Mutually Exclusive: Cannot register for MECH 488 if student has credit for MECH 588.**MECH 489 - MICROFLUIDICS: FUNDAMENTALS AND APPLICATIONS****Short Title:** MICROFLUIDICS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Prerequisite(s):** MECH 371**Description:** This course presents an introduction to microfluidics, including theoretical analysis of microscale flows, basic understanding of microscale properties, fabrication processes for microfluidic devices and an overview of common applications, many of which are relevant for bioprocessing and biodetection. Basic understanding of physics, chemistry, intermediate calculus and fluid mechanics is required. Graduate/Undergraduate Equivalency: MECH 589.**MECH 490 - MECHANICAL ENGINEERING RESEARCH PROJECTS****Short Title:** MECH ENG RESEARCH PROJECTS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Research**Credit Hours:** 1-4**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Description:** Independent investigation of a specific topic or problem in mechanical engineering. Research under the direction of a selected faculty member. Instructor Permission Required. Repeatable for Credit.

MECH 497 - NEUROMUSCULOSKELETAL MODELING AND SIMULATION**Short Title:** NEUROMUSCULOSKELETAL MODELING**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Prerequisite(s):** (MECH 211 or CEVE 211 or MECH 310) and (CAAM 210 or CMOR 220)**Description:** Introduction to computer modeling and simulation of the human neuromusculoskeletal system. Topics include measurement of human movement, 3D kinematic modeling, inverse and forward dynamic simulations, muscle and joint contact force estimation, and neural control modeling. Programming proficiency in Matlab required. Graduate/Undergraduate Equivalency: MECH 597. Mutually Exclusive: Cannot register for MECH 497 if student has credit for MECH 597.**MECH 498 - INTRODUCTION TO ROBOTICS****Short Title:** INTRODUCTION TO ROBOTICS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture/Laboratory**Credit Hours:** 3**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Prerequisite(s):** MATH 354 or MATH 355 or CAAM 335 or CMOR 302**Description:** The course will provide the student with a mathematical introduction to many of the key ideas used in today's intelligent robot systems. The focus of the course is on the analysis and control of manipulators. The course will also give an overview of common approaches to building intelligent robot systems. Cross-list: COMP 498, ELEC 498. Graduate/Undergraduate Equivalency: MECH 598. Recommended Prerequisite(s): MECH 211 or CEVE 211 or MECH 310. Mutually Exclusive: Cannot register for MECH 498 if student has credit for MECH 598.**MECH 499 - CURRENT TOPICS****Short Title:** CURRENT TOPICS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.**Course Level:** Undergraduate Upper-Level**Description:** Designed for undergraduate mechanical engineering students. Lectures in areas of current interest in mechanical engineering. Topics vary from term to term. Repeatable for Credit.**MECH 500 - ADVANCED MECHANICS OF MATERIALS****Short Title:** ADV MECHANICS OF MATERIALS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate**Prerequisite(s):** (MECH 211 or CEVE 211) and (MECH 311 or CEVE 311)**Description:** Advanced topics in solid mechanics and strength of materials including energy methods, principle of virtual work, conservation laws, constitutive modeling, aspects of elasticity theory, stability and fracture mechanics with application to the analysis and design of reliable structures. Cross-list: CEVE 500. Graduate/Undergraduate Equivalency: MECH 400. Mutually Exclusive: Cannot register for MECH 500 if student has credit for MECH 400.**MECH 501 - DYNAMICS AND CONTROL OF MECHANICAL SYSTEMS****Short Title:** DYNAMICS & CONTROL OF MECH SYS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate**Prerequisite(s):** MECH 343 and MECH 420**Description:** Graduate version of MECH 411. Offered continually with MECH 411. Graduate/Undergraduate Equivalency: MECH 411. Mutually Exclusive: Cannot register for MECH 501 if student has credit for MECH 411.**MECH 502 - VIBRATIONS****Short Title:** VIBRATIONS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate**Prerequisite(s):** MECH 343**Description:** Term project is required. Graduate/Undergraduate Equivalency: MECH 412. Mutually Exclusive: Cannot register for MECH 502 if student has credit for MECH 412.**MECH 503 - COMPUTER AIDED DESIGN****Short Title:** COMPUTER AIDED DESIGN**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture/Laboratory**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate**Description:** Investigation of the integration of the computer into the area of design. Includes such subjects as optimization, finite element analysis, and commercial software. Graduate/Undergraduate Equivalency: MECH 403. Mutually Exclusive: Cannot register for MECH 503 if student has credit for MECH 403.

MECH 505 - NUMERICAL METHODS FOR ENGINEERS**Short Title:** NUMERICAL METHODS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate

Description: Numerical methods are the computational solution of mathematical problems. This course focuses on developing a competency in the four basic areas of numerical methods: differentiation, integration, optimization, and continuation. These four categories of methods form a tool set that are used throughout the computational solution of engineering problems.

MECH 508 - NONLINEAR SYSTEMS: ANALYSIS AND CONTROL**Short Title:** NONLINEAR SYSTEMS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate

Description: Mathematical background and fundamental properties of nonlinear systems: Vector norms, matrix norms, matrix measures, existence and uniqueness of solutions of ordinary differential equations. Linearization, second order systems, periodic solutions, approximate methods. Lyapunov stability: Stability definitions, Lyapunov's direct method, invariance theory, stability of linear systems, Lyapunov's linearization method, converse theorems. Selected topics in nonlinear systems analysis and nonlinear control from: Input/Output stability: Small gain theorem, passivity theorem. Perturbation theory, averaging, and singular perturbations Feedback linearization control. Other methods in the control of nonlinear systems such as backstepping, sliding mode and other Lyapunov-based design methods. Advanced nonlinear and adaptive robot control. Cross-list: CMOR 508, ELEC 508.

MECH 510 - ELASTO DYNAMICS**Short Title:** ELASTO DYNAMICS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate

Description: Propagation of waves in linearly-elastic strings, fluids, and solids. Surface waves, wave reflection and refraction at interfaces. Wave propagation in waveguides. Steady-state and transient half-space problems. Scattering of waves by cracks.

MECH 517 - FINITE ELEMENT ANALYSIS**Short Title:** FINITE ELEMENTS ANALYSIS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate

Prerequisite(s): (MATH 212 or MATH 222) and (CAAM 210 or CAAM 211 or CMOR 220)

Description: An introduction to Galerkin's method and the method of least squares applied to partial differential equations. Computational considerations for efficient interpolation, numerical integration, solution and post-processing methods. Error estimation and adaptive finite element analysis. Requires the use of solid works for a student project and a supporting literature survey. Cross-list: CEVE 517. Graduate/ Undergraduate Equivalency: MECH 417. Mutually Exclusive: Cannot register for MECH 517 if student has credit for MECH 417.

MECH 519 - ELASTICITY, PLASTICITY AND DAMAGE MECHANICS**Short Title:** ELASTICITY/PLASTICITY/DAMAGE**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture/Laboratory**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate

Description: An overview of phenomena that determine the response of solids to deformation and loading: elasticity, plasticity, damage mechanics and cracking. Review of continuum mechanics with emphasis on the physical mechanisms of deformation and fracture. Classification of the behavior of solids. Modeling of different types of material behavior. The physics underlying the phenomena and methods for the numerical analysis of the resulting equations are discussed. Cross-list: CEVE 519.

MECH 520 - NONLINEAR FINITE ELEMENT ANALYSIS**Short Title:** NONLINEAR FEM**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate

Description: Formulation and solution of nonlinear initial/boundary value problems using the finite element method. Variational principles for nonlinear problems, finite element discretization, and equation-solving strategies for discrete nonlinear equation systems. Applications include: materially nonlinear systems, geometrically nonlinear systems, transient nonlinear problems, and treatment of non smooth constraints in a nonlinear framework. Cross-list: CEVE 503.

MECH 523 - PROBABILISTIC STRUCTURAL DYNAMICS**Short Title:** PROB STRUCTURAL DYNAMICS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture/Laboratory**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate**Prerequisite(s):** MECH 412 or CEVE 521

Description: Introduction to probability theory and random processes. Includes the dynamic analysis of linear and nonlinear structural systems subjected to stationary and nonstationary random excitations reliability studies related to first excursion and fatigue failures, and applications to earthquake engineering, offshore engineering, and wind engineering. Recommended prerequisite(s): Basic knowledge of probability theory.

MECH 524 - ENGINEERING MATHEMATICAL AND NUMERICAL METHODS**Short Title:** ENGR MATH & NUMERICAL METHODS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate

Description: Elements of linear algebra, linear operators, systems of linear differential equations for discrete physical systems, calculus of variations, partial differential equations, Green's functions, examples from solid and fluid mechanics, discretization of continuous systems, finite element method.

MECH 527 - PHYSICS GUIDED MACHINE LEARNING & DATA DRIVEN MODELING FEM**Short Title:** PHY GUIDED ML- DATA DRIVEN FEM**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate**Prerequisite(s):** CEVE 311 or MECH 311 or MECH 315

Description: Introduction to physics guided machine learning and data driven modeling from a rigorous finite element analysis and system dynamics (& optimization) perspective. Programming needed will be introduced in the course. The course involves series of assignments involving programming. Project work will be assigned at the end of the semester in lieu of the final exam. Students in CEVE 527 (GR version) will be required to do more advanced assignments and a project. Prerequisites CEVE/MECH 311. Cross-list: CEVE 527. Mutually Exclusive: Cannot register for MECH 527 if student has credit for MECH 427.

Course URL: Satishnagarajaiah.rice.edu (<http://Satishnagarajaiah.rice.edu>)

MECH 530 - TRIBOMECHADYNAMICS**Short Title:** TRIBOMECHADYNAMICS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate

Description: Tribomechadynamics is a graduate/upper level undergraduate course that spans the topics of tribology, contact mechanics, and nonlinear dynamics. These three topics are integral to understanding interfacial contact, how assembled structures behave, and how the evolution of damage (wear) over time at the micro-scale influences the structural-scale response of a system. In brief, the subjects covered by this course are: • Tribology. Topics will include empirical and heuristic friction models, the fundamentals of wear, lubrication selection and considerations, and fundamental failure modes. • Contact Mechanics. Topics will include elastic deformation, constitutive modeling, plasticity, failure criteria, and numerical simulation. • Nonlinear Dynamics. Topics will include an overview of linear vibration theory, model reduction theories, nonlinear vibration theory, nonlinear analysis including quasi-static analysis and harmonic balance methods, continuation, and modal analysis. Graduate/Undergraduate Equivalency: MECH 430.

MECH 537 - DESIGN AND CONTROL OF COMPUTER NETWORKS**Short Title:** COMMUNICATION NETWORKS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate

Description: Graduate-level introduction to design and analysis of communication networks. Topics include wireless networks, medium access, routing, traffic modeling, congestion control, and scheduling. Cross-list: ELEC 537.

MECH 544 - FLUID MECHANICS OF COMPUTING**Short Title:** FLUID MECHANICS OF COMPUTING**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate

Description: The objective is to learn and develop a good understanding of the fluid mechanics concepts and tools that are essential to know for successful computational flow analysis. For successful computational flow analysis, we first have to know the problem we want to solve, set up the computational conditions correctly, have a good idea about what results to expect, and properly interpret and evaluate the computed results. This course will help us learn the fluid mechanics concepts and tools required for that. The course will have both an easy to follow mathematical approach and an easy to relate to physical-interpretation approach. The topics covered include the basic mathematical framework, key fluid mechanics mechanisms, scaling and nondimensional variables and equations, and simple fluid mechanics formulas that can be used in obtaining analytical estimates to the problems solved. Additional work required for MECH 544. Graduate/Undergraduate Equivalency: MECH 444. Mutually Exclusive: Cannot register for MECH 544 if student has credit for MECH 444. Graduate/Undergraduate Equivalency: MECH 444. Recommended Prerequisite(s): MECH 200 and MATH 212. Mutually Exclusive: Cannot register for MECH 544 if student has credit for MECH 444.

MECH 550 - ALGORITHMIC ROBOTICS**Short Title:** ALGORITHMIC ROBOTICS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 4**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate**Prerequisite(s):** COMP 321 and COMP 215

Description: Robots have fascinated people for generations. Today, robots are built for applications as diverse as exploring remote planets, de-mining war zones, cleaning toxic waste, assembling cars, inspecting pipes in industrial plants and mowing lawns. Robots are also interacting with humans in a variety of ways: robots are museum guides, robots assist surgeon in life threatening operations, and robotic cars can drive us around. The field of robotics studies not only the design of new mechanisms but also the development of artificial intelligence frameworks to make these mechanism useful in the physical world, integrating computer science, engineering, mathematics and more recently biology and sociology, in a unique way. This class will present fundamental algorithmic advances that enable today's robots to move in real environments and plan their actions. It will also explore fundamentals of the field of Artificial Intelligence through the prism of robotics. The class involves a significant programming project. Cross-list: COMP 550, ELEC 550. Graduate/Undergraduate Equivalency: MECH 450. Mutually Exclusive: Cannot register for MECH 550 if student has credit for MECH 450.

MECH 554 - COMPUTATIONAL FLUID MECHANICS**Short Title:** COMPUTATIONAL FLUID MECHANICS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate

Prerequisite(s): MECH 371 (may be taken concurrently) or MECH 444 (may be taken concurrently) or CEVE 363 (may be taken concurrently) or CHBE 401 (may be taken concurrently) or BIOE 420 (may be taken concurrently) or CHBE 420 (may be taken concurrently)

Description: Fundamental concepts of finite element methods in fluid mechanics, including spatial discretization and numerical integration in multidimensions, time-integration, and solution of nonlinear ordinary differential equation systems. Advanced numerical stabilization techniques designed for fluid mechanics problems. Strategies for solution of complex, real-world problems. Topics in large-scale computing, parallel processing, and visualization. Prerequisites may be taken concurrently. Additional work required. Cross-list: BIOE 554, CEVE 554. Graduate/Undergraduate Equivalency: MECH 454. Mutually Exclusive: Cannot register for MECH 554 if student has credit for MECH 454.

MECH 555 - COMPUTATIONAL FLUID-STRUCTURE INTERACTION**Short Title:** COMPUTATIONAL FSI**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate

Prerequisite(s): (MECH 454 or BIOE 454 or CEVE 454) or (MECH 554 or BIOE 554 or CEVE 554)

Description: Components and challenges of fluid-structure interaction (FSI) computations. Finite element methods for flows with moving interfaces; space-time techniques. Fluid-structure interface projection techniques. Mesh moving and remeshing techniques. FSI coupling techniques for fluid, structure, and mesh equation blocks. FSI computation sequences. FSI contact algorithms, multiscale FSI, cardiovascular FSI, and parachute FSI.

MECH 556 - LEGAL THEMES IN ENGINEERING AND MANAGING PRACTICE**Short Title:** LEGAL THEMES IN ENGI PRACTICES**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate

Description: Introduction to fundamental legal concepts of the American legal system for upper level undergraduate students, primarily aimed at what engineers, scientists and other professionals could expect to encounter in their professional careers. The primary focus is to provide students with the basic tools to understand and interact with lawyers. Mutually Exclusive: Cannot register for MECH 556 if student has credit for MECH 456.

MECH 560 - TRIBOLOGY: THE STUDY OF FRICTION, LUBRICATION, AND WEAR**Short Title:** TRIBOLOGY**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate

Description: Tribology is the interdisciplinary study of interacting surfaces from the nanoscale to the macro-scale. These surfaces undergo friction and wear and sometimes, have fluids between them for lubrication. This course will occur mainly in two parts: (i) Contact Mechanics, (ii) Hydrodynamic (fluid) lubrication. Fundamental topics include friction, wear, heat transfer within interfaces, thin-film lubrication and computational Tribology.

MECH 566 - SYSTEM IDENTIFICATION OF DYNAMIC SYSTEMS WITH MACHINE LEARNING**Short Title:** SYSTEM I.D. & MACHINE LEARNING**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture/Laboratory**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate**Prerequisite(s):** CEVE 311 or MECH 311 or MECH 315

Description: Introduction to modeling and system identification of dynamic systems with machine learning. Students in CEVE 596/ MECH 566 will be required to do more advanced assignments and a project. Cross-list: CEVE 596. Graduate/Undergraduate Equivalency: MECH 466.

MECH 572 - AEROSPACE SYSTEMS ENGINEERING**Short Title:** AEROSPACE SYSTEMS ENGINEERING**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate

Description: Integration of engineering problem solving methodologies based on systems concepts. Applications to complex, large scale aerospace systems and problems faced by engineering managers. Recommended Prerequisite(s): MECH 472 and MECH 594.

MECH 573 - ADVANCED FLUID MECHANICS I**Short Title:** ADVANCED FLUID MECHANICS I**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate

Description: Additional work required. Graduate/Undergraduate Equivalency: MECH 473. Mutually Exclusive: Cannot register for MECH 573 if student has credit for MECH 473.

MECH 574 - TURBULENCE**Short Title:** TURBULENCE**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate

Description: Study of the fundamentals of fluid dynamic turbulence including origins, nature, turbulent transport of momentum and heat, statistical description, spectral dynamics, and numerical modeling.

MECH 575 - INTRODUCTION TO HYDRODYNAMIC STABILITY**Short Title:** INTRO HYDRODYNAMIC STABILITY**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate

Description: Introduction to linear and nonlinear instabilities that cause transition from laminar to turbulent flows in thermos-fluid systems. The physics of various canonical instability mechanisms and the mathematical and numerical frameworks common in stability analysis are discussed. Examples from industrial, geophysical, environmental, and astrophysical flows are presented. Recommended Prerequisite(s): MECH 371 or CEVE 363 or EEPs 465 or CMOR 410 or CHBE 401. Repeatable for Credit.

MECH 576 - STRUCTURAL DYNAMIC SYSTEMS**Short Title:** STRUCTURAL DYNAMIC SYSTEMS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate

Description: Introduction to structural dynamic systems. Linear SDOF and MDOF discrete systems, undamped and damped systems, free and forced vibration, dynamic response to periodic and arbitrary excitations, numerical evaluation of dynamic response, response spectrum and modal analysis. Additional topics for graduate version 576: Linear systems theory, transform methods, state space methods, feedback control, observers and identification. Applications using MATLAB. Demonstrations and laboratory examples. Students will be required to do more advanced assignments and a project. Cross-list: CEVE 576.

MECH 578 - ORBITAL MECHANICS AND MISSION DESIGN**Short Title:** ORBITAL MECHANICS AND MISSION**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate**Prerequisite(s):** MECH 343

Description: Develop an understanding of orbital mechanics. Obtain a detailed knowledge of the two-body problem and its solutions with applications to geocentric orbits and interplanetary transfers. Understand the concept of impulsive thrusting and its use in orbital transfers including plane changes. Obtain a knowledge of time-of-flight relations on two-body trajectories, using both classical and universal variables.

MECH 579 - LAUNCH VEHICLE AND SPACECRAFT DESIGN**Short Title:** LV AND SPACECRAFT DESIGN**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate

Description: This course examines the design of launch vehicles and spacecraft, including the impacts of the atmosphere and the space environment on requirements and configurations. The principles and design aspects of the structure, propulsion, power, thermal, communication, and control subsystems will be examined.

MECH 580 - MECHANICS AND KINEMATICS OF RESPIRATORY MUSCLE IN OBESITY**Short Title:** RESPIRATORY MECH IN OBESITY**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate

Description: The course is designed to understand unique aspects of remodeling the respiratory system mechanics in obesity. Focus will be on remodeling of diaphragm muscle and chest wall as a consequence of obesity. In particular, alteration in the kinematics and mechanics of the diaphragm in obese subjects will be evaluated.

MECH 581 - MICRO AND NANO HEAT TRANSPORT METHODOLOGIES AND DESIGN**Short Title:** MICRO & NANO HEAT TRANSPORT**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3

Restrictions: Enrollment is limited to students with a major in Mechanical Engineering or Materials Science & NanoEng. Enrollment is limited to Graduate level students.

Course Level: Graduate**Prerequisite(s):** MECH 481

Description: A thorough explanation of the methodologies used for solving conduction, convection and radiation heat transport problems in macro, micro and nanosystems. Phonon, photon and electron transfer fundamentals. Equilibrium Statistics. Basic kinetic theory and transport properties of ideal gases. Microchannel heat transfer. Nanofluid heat transfer. Non-Fourier heat Conduction. Boltzmann transport equation. Molecular dynamics and lattice dynamics numeric methods. Applications and design problems in contemporary technologies. To be taught alternating years for MECH and MSNE Seniors and Graduate students. Cross-list: MSNE 581.

MECH 582 - CONVECTIVE HEAT TRANSFER**Short Title:** CONVECTIVE HEAT TRANSFER**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate

Description: Rigorous study of the transfer of heat by free and forced convection. Graduate/Undergraduate Equivalency: MECH 482. Mutually Exclusive: Cannot register for MECH 582 if student has credit for MECH 482.

MECH 584 - MICROSCOPIC THERMODYNAMICS AND TRANSPORT**Short Title:** MICRO THERMO & TRANSPORT**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate

Description: This course introduces concepts in statistical mechanics and non-equilibrium thermodynamics that are used to understand the physical mechanisms of heat transfer, particularly in micro/nanoscale systems. Emphasis is placed on energy storage and thermal transport by electrons, phonons, molecules, and photons. Topics include the kinetic theory of gases, thermodynamic distribution functions, energy carrier dispersion relations, Boltzmann equation modeling of thermal and electrical properties, size effects (classical and quantum-mechanical) on material properties, and thermoelectric energy conversion. Graduate/Undergraduate Equivalency: MECH 484.

MECH 586 - RESPIRATORY SYSTEM MECHANICS**Short Title:** RESPIRATORY SYSTEM MECHANICS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate

Description: Mechanics of ventilation, respiratory muscle mechanics, rib cage mechanics, mechanical coupling between the respiratory muscles and the rib cage, and inferences on mechanics from respiratory muscle anatomy. The class will meet in the Pulmonary Division at Baylor College of Medicine in the Texas Medical Center. Cross-list: BIOE 586.

MECH 587 - INTERFACIAL PHENOMENA, CAPILLARITY, AND WETTING**Short Title:** CAPILLARITY AND WETTING**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate

Description: This course will provide the fundamental knowledge required for students to analyze, model, and design systems based on interfacial phenomena, with applications including wetting, enhanced oil recovery, cosmetics, pharmaceuticals, microfluidic devices, phase change heat transfer, and even everyday food and drink. After completing this course, students will exhibit a strong understanding of surface tension and surface energy, adsorption and adhesion, surface-tension-driven flows, capillarity, capillary instabilities, contact angle, fluid spreading, wetting of textured surfaces leading to superhydrophobicity and superhydrophilicity, and self-cleaning surfaces. Graduate/Undergraduate Equivalency: MECH 487. Recommended Prerequisite(s): MECH 200 (or equivalent) and MECH 371 (or equivalent) Mutually Exclusive: Cannot register for MECH 587 if student has credit for MECH 487.

MECH 588 - DESIGN OF MECHATRONIC SYSTEMS**Short Title:** DESIGN OF MECHATRONIC SYSTEMS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate

Description: Additional work required. Graduate/Undergraduate Equivalency: MECH 488. Mutually Exclusive: Cannot register for MECH 588 if student has credit for MECH 488.

MECH 589 - MICROFLUIDICS: FUNDAMENTALS AND APPLICATIONS**Short Title:** MICROFLUIDICS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate

Description: This course presents an introduction to microfluidics, including theoretical analysis of microscale flows, basic understanding of microscale properties, fabrication processes for microfluidic devices and an overview of common applications, many of which are relevant for bioprocessing and biodetection. Basic understanding of physics, chemistry, intermediate calculus and fluid mechanics is required. Additional work required for Graduate course. Graduate/Undergraduate Equivalency: MECH 489.

MECH 590 - AEROSPACE PROPULSION**Short Title:** AEROSPACE PROPULSION**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate

Description: Aspects of one-dimensional compressible flow, including isentropic flow and normal shocks; effects of friction and combustion; analysis and design of air-breathing and rocket engines, including performance and cycle analysis; flow in nozzles, diffusers, compressors, and turbines; combustion chamber processes and propellants.

MECH 591 - GAS DYNAMICS**Short Title:** GAS DYNAMICS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate**Prerequisite(s):** MECH 371

Description: Study of the fundamentals of compressible, one-dimensional gas flows with area change, normal shocks, friction, and heat addition. Includes oblique shocks, Prandtl-Meyer flows expansions, and numerical techniques.

MECH 592 - DESIGN FOR AEROSPACE ENVIRONMENTS**Short Title:** AEROSPACE ENVIRONMENTS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate

Description: Graduate course on aerospace environments, including theoretical bases. Topics include key mission phases, orbital mechanics, the effects of the sun, plasma, particles and ionizing radiation, neutral atmosphere, contamination, micrometeoroid/orbital debris, thermal and aerothermal environments. Extraterrestrial environments are briefly discussed. Cross-list: NSCI 591.

MECH 593 - MECHANICAL ENGINEERING PROBLEMS**Short Title:** MECH ENGINEERING PROBLEMS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Independent Study**Credit Hours:** 3

Restrictions: Enrollment is limited to students with a major in Mechanical Engineering. Enrollment is limited to Graduate level students.

Course Level: Graduate

Description: An approved investigation or design project under the direction of a member of the staff. Open only to mechanical engineering majors. Repeatable for Credit.

MECH 594 - INTRODUCTION TO AERONAUTICS**Short Title:** INTRODUCTION TO AERONAUTICS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate**Prerequisite(s):** MECH 371**Description:** Development of theories for the prediction of aerodynamic forces and moments acting on airfoils, wings, and bodies. Includes their design applications.**MECH 595 - MODELING TISSUE MECHANICS****Short Title:** MODELING TISSUE MECHANICS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Independent Study**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate**Description:** Independent study and seminar course which focuses on modeling the mechanical properties of biological tissues. Data from experiments will be used to refine the predictions of nonlinear mathematical computer models. Aimed at juniors, seniors, and graduate students. Laboratory work performed at Baylor College of Medicine, computer work at Rice University. Cross-list: BIOE 595.**MECH 596 - INTRODUCTION TO FLIGHT MECHANICS****Short Title:** INTRO TO FLIGHT MECHANICS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate**Prerequisite(s):** MECH 371 or CEVE 371**Description:** This course will examine the basic flight mechanics of aircraft and spacecraft. Simulation exercises will be conducted to illustrate the principles. Recommended Prerequisite(s): MECH 594**MECH 597 - NEUROMUSCULOSKELETAL MODELING AND SIMULATION****Short Title:** NEUROMUSCULOSKELETAL MODELING**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate**Description:** Introduction to computer modeling and simulation of the human neuromusculoskeletal system. Topics include measurement of human movement, 3D kinematic modeling, inverse and forward dynamic simulations, muscle and joint contact force estimation, and neural control modeling. Programming proficiency in Matlab required. Additional work required for Graduate course. Graduate/Undergraduate Equivalency: MECH 497. Mutually Exclusive: Cannot register for MECH 597 if student has credit for MECH 497.**MECH 598 - INTRODUCTION TO ROBOTICS****Short Title:** INTRODUCTION TO ROBOTICS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture/Laboratory**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate**Description:** Introduction to the kinematics, dynamics, and control of robot manipulators and to applications of artificial intelligence and computer vision in robotics. Additional work required for Graduate course. Cross-list: COMP 598, ELEC 598. Graduate/Undergraduate Equivalency: MECH 498. Mutually Exclusive: Cannot register for MECH 598 if student has credit for MECH 498.**MECH 599 - CURRENT TOPICS IN MECHANICAL ENGINEERING****Short Title:** SPECIAL TOPICS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate**Description:** Designed for senior and graduate level students. Lectures in areas of current interest in mechanical engineering. Topics may vary from term to term. Fall 2019, Section 003: This course focuses on numerical techniques for solving partial differential equations (PDEs) including the full incompressible Navier-Stokes equations. Several spatial-temporal discretization methods will be taught, primarily the finite difference method, but also moderate exposure to the finite volume method, and light exposure to the finite element method. Explicit and implicit approaches, in addition to methods to solve linear equations are employed to study fluid flows. A review of various finite difference methods which will be used to analyze elliptic, hyperbolic, and parabolic partial differential equations and the concepts of stability, consistency and convergence are taught to familiarize the students with general numerical PDE methods. Commercial computational fluid dynamics (CFD) software used in the field will be briefly introduced. Repeatable for Credit.**MECH 601 - SPECIAL TOPICS****Short Title:** SPECIAL TOPICS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 1-9**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate**Description:** Topics may vary. Please consult with the department for additional information. FA 2016, Section 001: Special Topics: Advanced Topics and Tools in Particle Flows & Tribology. Instructor Permission Required.**MECH 602 - SPECIAL TOPICS****Short Title:** SPECIAL TOPICS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 1-9**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate**Description:** Topics may vary. Please consult with the department for additional information.

MECH 606 - GRADUATE SEMINAR**Short Title:** GRADUATE SEMINAR**Department:** Mechanical Engineering**Grade Mode:** Satisfactory/Unsatisfactory**Course Type:** Seminar**Credit Hour:** 1**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate**Description:** Repeatable for Credit.**MECH 611 - INDEPENDENT STUDY****Short Title:** INDEPENDENT STUDY**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Independent Study**Credit Hours:** 1-9**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate**Description:** Repeatable for Credit.**MECH 612 - INDEPENDENT STUDY****Short Title:** INDEPENDENT STUDY**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Independent Study**Credit Hours:** 1-9**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate**Description:** Repeatable for Credit.**MECH 620 - FUNDAMENTALS OF CONTROL SYSTEMS****Short Title:** FUNDAMENTALS OF CONTROL SYST**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate

Description: Linear systems and the fundamental principles of classical feedback control, state variable analysis of linear dynamic systems, stability of linear control systems, time-domain analysis and control of linear systems, root-locus analysis and design and pole-zero synthesis, frequency domain techniques for the analysis and design of control systems. Required for mechanical engineering majors in B.S. program. Additional work required for MECH 620. Cannot be taken if MECH 420 or ELEC 436 was previously taken. Instructor Permission Required. Graduate/Undergraduate Equivalency: MECH 420. Mutually Exclusive: Cannot register for MECH 620 if student has credit for MECH 420.

MECH 621 - M.M.E. RESEARCH PROJECT I**Short Title:** M.M.E. RESEARCH PROJECT I**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Research**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate

Description: This is the first part of the M.M.E. research project course. The faculty advisor, taking into account the background and research interests of the student as well as the research interests of the faculty advisor, will determine the contents. Course requirements will include a final report. Instructor Permission Required.

MECH 622 - M.M.E. RESEARCH PROJECT II**Short Title:** M.M.E. RESEARCH PROJECT II**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Research**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate

Description: This is the second part of the M.M.E. research project and continuation of MECH 621. Course requirements will include a final report.

MECH 654 - ADVANCED COMPUTATIONAL MECHANICS**Short Title:** ADV COMPUTATIONAL MECHANICS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate

Prerequisite(s): BIOE 554 or BIOE 454 or CEVE 554 or CEVE 454 or MECH 554 or MECH 454

Description: Advanced topics in computational mechanics with emphasis on finite element methods and fluid mechanics. Stabilized formulations. Fluid-particle and fluid-structure interactions and free-surface and two-fluid flows. Interface-tracking and interface-capturing techniques, space-time formulations, and mesh update methods. Enhanced discretization and solution techniques. Iterative solution methods, matrix-free computations, and advanced preconditioning techniques. Cross-list: BIOE 654, CEVE 654. Graduate/Undergraduate Equivalency: MECH 474. Mutually Exclusive: Cannot register for MECH 654 if student has credit for MECH 474.

MECH 665 - ANALYSIS OF VIBRATIONS IN NONLINEAR SYSTEMS**Short Title:** NONLINEAR VIBRATIONS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate**Prerequisite(s):** MECH 502

Description: Nonlinear vibrations are studied in structural and mechanical systems. Methods for the qualitative and quantitative analysis of these systems are applied. The classification and stability of equilibrium and periodic solutions are discussed for continuous time systems and discrete maps. Floquet theory and Poincare maps are used to study periodic behavior.

MECH 667 - NONLINEAR DYNAMIC BEHAVIOR IN MECHANIC SYSTEMS AND STRUCTURES**Short Title:** NONLINEAR DYNAMICS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate**Prerequisite(s):** MECH 502

Description: Various types of nonlinear dynamic behavior are studied in mechanical systems and structures. The course will focus mainly on quasi-periodic and chaotic behavior but will also include periodic behavior. Modeling and analysis methods will be discussed for both discrete and continuous time systems including Lyapunov exponents and pseudo-state space. Recommended Prerequisite(s): MECH 665

MECH 677 - SPECIAL TOPICS**Short Title:** SPECIAL TOPICS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Independent Study, Internship/Practicum, Laboratory, Lecture, Seminar, Lecture/Laboratory**Credit Hours:** 1-4**Restrictions:** Enrollment is limited to Graduate or Visiting Graduate level students.**Course Level:** Graduate

Description: Topics and credit hours vary each semester. Contact department for current semester's topic(s). Repeatable for Credit.

MECH 678 - APPLIED STOCHASTIC MECHANICS**Short Title:** APPLIED STOCHASTIC MECHANICS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate

Description: Nonlinear random vibrations, Statistical Linearization, ARMA filters modeling, Monte Carlo Simulation, Wiener-Volterra series, time-variant structural reliability, and Stochastic Finite Elements are presented from a perspective of usefulness to aerospace, civil, marine, and mechanical applications. Cross-list: CEVE 678.

MECH 679 - APPLIED MONTE CARLO ANALYSIS**Short Title:** APPLIED MONTE CARLO ANALYSIS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate

Description: Probability density and power spectrum based simulation concepts and procedures are discussed. Scalar and vectorial simulation are addressed. Spectral decomposition and digital filter algorithms are presented. Applications from aerospace, earthquake, marine, and wind engineering, and from other applied science disciplines are included. Cross-list: CEVE 679.

MECH 683 - RADIATIVE HEAT TRANSFER I**Short Title:** RADIATION HEAT TRSF I**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate

Description: Rigorous study of the transfer of heat by radiant exchange in the absence of absorbing media.

MECH 691 - INTRODUCTION TO HYPERSONIC AERODYNAMICS**Short Title:** INTRO TO HYPERSONICS**Department:** Mechanical Engineering**Grade Mode:** Standard Letter**Course Type:** Lecture**Credit Hours:** 3**Restrictions:** Enrollment is limited to Graduate level students.**Course Level:** Graduate**Description:** Recommended Prerequisite(s): MECH 591.**MECH 800 - RESEARCH AND THESIS****Short Title:** RESEARCH AND THESIS**Department:** Mechanical Engineering**Grade Mode:** Satisfactory/Unsatisfactory**Course Type:** Research**Credit Hours:** 1-12

Restrictions: Enrollment is limited to students with a major in Mechanical Engineering. Enrollment is limited to Graduate level students.

Course Level: Graduate**Description:** Repeatable for Credit.

Description and Code Legend

Note: Internally, the university uses the following descriptions, codes, and abbreviations for this academic program. The following is a quick reference:

Course Catalog/Schedule

- Course offerings/subject code: MECH

Department Description and Code

- Mechanical Engineering: MECH

Undergraduate Degree Descriptions and Codes

- Bachelor of Arts degree: BA
- Bachelor of Science degree: BSME

Undergraduate Major Description and Code

- Major in Mechanical Engineering (attached to both the BA and BSME Degrees): MECH

Undergraduate Major Areas of Specialization Descriptions and Attribute Codes*

- Area of Specialization in Computational Engineering (BSME degree only): MECE
- Area of Specialization in Mechanics/Dynamics (BSME degree only): MEMD
- Area of Specialization in Thermal Fluids (BSME degree only): METF

- Area of Specialization in Breadth in Mechanical Engineering (BSME degree only): MEBR

Please Note: Areas of Specialization are department/program-specific and are not formally recognized academic credentials. Unlike Major Concentrations, Areas of Specialization do not appear on the student's official academic transcript, etc. Students may informally choose to follow more than one Area of Specialization (or pre-specified collections of elective courses), however, when declaring their major they should identify and declare one Area of Specialization with the Office of the Registrar.

Graduate Degree Descriptions and Codes

- Master of Mechanical Engineering degree: MME
- Master of Science degree: MS
- Doctor of Philosophy degree: PhD

Graduate Degree Program Description and Code

- Degree Program in Mechanical Engineering: MECH

CIP Code and Description ¹

- **MECH** Major/Program: CIP Code/Title: 14.1901 - Mechanical Engineering

* *Systems Use Only: this information is used solely by internal offices at Rice University (such as OTR, GPS, etc.) and primarily within student information systems and support.*

¹ Classification of Instructional Programs (CIP) 2020 Codes and Descriptions from the National Center for Education Statistics: <https://nces.ed.gov/ipeds/cipcode/>