**Advanced Engineering Technical Electives**

**Fall 2024**

ME 590 Fluid Systems & Gas Dynamics Pre: ME 510 Dr. Bergman

ME 590 Intro Scan Electron Microscope Pre: ME 455 Dr. Liu

ME 627 Automotive Design Pre: ME 617 Dr. Sorem Required for JMS

ME 633 Basic Biomechanics Pre: ME 311 and ME 320 Dr. Fischer Required for BIOE

ME 702 Mechanical Engineering Analysis Pre: MATH 220 Dr. Yang

ME 712 Adv Engineering Thermodynamics Pre: ME 212\* Dr. Depcik

ME 716 Intro to Surface & Interface Science Pre: ME 212 Dr. Kwon

ME 722 Modeling Dynamics Mech Systems Pre: ME 320 Dr. Luchies

ME 736 Catalytc Exhst Aftertrtmnt Mod Pre: ME 510 Dr. Depcik

ME 754 Medical Imaging Pre: ME 508 Dr. Yang BIOE

ME 765 Biomaterials Pre: ME 306 Dr. Tamerler BIOE

ME 789 Energy Storage Systems & Control Pre: ME 682 Dr. Fang

ME 790 Mechanical Metallurgy Pre: ME 306, ME 311; Co: ME 307 Dr. Pourladian

\* ME 212 grade of C- or better.

**Spring 2025 (tentative)**

ME 608/708 Intro to Mechatronics / Mechatronics Pre: ME 208,320 Dr. Wilson

ME 696 Design for Manufacturability Pre: ME 501 Dr. Maletsky

ME 750 Biomechanics of Human Motion Pre: ME 320 Dr. Luchies BIOE

ME 752 Acoustics Pre: ME 320 Dr. Yang

ME 755 Computer Simulation in BIOM Pre: ME 311 and 320 Dr. Fischer BIOE

ME 760 Biomedical Product Development Pre: Senior Dr. Friis BIOE

ME 790 Advanced Heat & Mass Transfer Pre: ME 612 Dr. Bergman

ME 790 Characterization of Materials Pre: ME 306 Dr. Spencer

ME 797 Materials for Energy Applications Pre: ME 212\* Dr. Liu

Updated: 3/20/2024

**Fall 2024**

**ME 590 Fluid Systems & Gas Dynamics**

One-third of the course will extend the coverage of ME 510 to include rotating machinery (fans, pumps) and practical fluid-handling issues and fluid-handling systems. The second two-thirds of the course will introduce the basic concepts of compressible fluid flow.

**Topics:** Reynolds Transport Theorem, Conservation of Mass and Linear Momentum (1 week); Conservation of Angular Momentum (1 week); Fluid Machinery (1 week); Fluid Handling and Pumping Systems (1 week); Thermodynamics and the Velocity of Sound (1 week); Isentropic Flow of Ideal Gases (1 week); Stationary Normal Shocks (1 week); Oblique Shocks (1 week); Prandtl-Meyer Flow and Supersonic Airfoils (1 week); Flow with Friction (1 week); Flow with Heat Transfer (1 week); Flow with Variable Area and Heat Transfer (1 week); In-class Examples and Problems (1.5 weeks); Examinations (1.5 weeks)

Prerequisite: ME 510

**ME 590 Intro Scan Electron Microscope**

The objectives of this course are to have students continue to develop a systematic approach to problem solving and critical thinking in a series of experiments to learn the techniques hands-on for scanning electron microscopy (SEM), X-ray microanalysis, and analytical electron microscopy. This hands-on course will build on your experiences in physics and chemistry, and measurements.

**Topics:** Electron Optical Column; Vacuum Systems; System Comparison; Signal Detection and Display; Image Formation and Interpretation of Signals; Analytical X-ray Microanalysis; Practical Things; Other Instruments

Prerequisite: ME 455

**ME 627 Automotive Design**

Basic concepts of automotive design and manufacture. Primary focus of course on vehicle design and performance. Design is subdivided into vehicle components of frame, suspension, front and rear axle, steering power train, front and rear wheel drive, and braking. Integration of these ideas into a vehicle design project with analysis of its performance culminates the course.

**Topics:** Vehicle Design: Chassis and frame; Suspension and steering; Front and rear axles and power train; Braking and vehicle dynamic performance; Design Project: Engineering specifications; Project scheduling; Concept generation and evaluation; Performance evaluation; Design for manufacture, assembly and implementation; Analysis (stress, thermal, economic, environmental, etc.)

Prerequisite: ME 617

**ME 633 Basic Biomechanics**

Provides an overview of musculoskeletal anatomy. Biodynamics includes linear and angular dynamics of human movement, energy expenditure, and power required to perform a given activity. Students will learn to determine joint forces and torques (in 2-D) from kinematic data for body segments and force plate data. The tissue mechanics section builds on ME 311.

**Topics:** Brief History of Biomechanics (1 week); Cellular Biomechanics (3 weeks); Tissue Biomechanics (5 weeks); Orthopedic pathologies, treatments, implants, and FDA considerations (2 weeks); Basic Dynamics applied to Human Motion (2 weeks); Cardiovascular Biomechanics (3 weeks); Extracellular Matrix Biomechanics (1 week)

Prerequisite: ME 311 and ME 320

**ME 702 Mechanical Engineering Analysis**

A study of advanced methods for engineering analysis of practical problems utilizing fundamental principles from engineering disciplines. The emphasis is on the solution of these problems and the interpretation and generalization of the results.

**Topics:** ODE review (1 week); Laplace transform techniques (2 weeks); Partial differential equations (analytical and [numerical, time permitting] solutions) (3 weeks); Eigenvalue problems (2 weeks); Matrices and vectors (1 week); Fourier transforms (1 week); Complex numbers, integration, residues (3 weeks); R^3 space and vector calculus (time permitting); Examinations and special topics (1-2 weeks)

Prerequisite: MATH 220

**ME 712 Adv Engineering Thermodynamics**

An advanced course in thermodynamics, mathematical in nature, with emphasis on a critical re-evaluation of the laws of thermodynamics, thermodynamics of one-dimensional gas flow, development of the classical thermodynamic relations and their application to engineering problems.

**Topics**: Review of basic thermodynamics (1 week); Reacting systems and chemical equilibrium (2 weeks); Thermodynamic relationships and real gas models (2 weeks); Exergy (2 weeks); One-dimensional gas flow and compressibility (3 weeks); Special thermodynamic systems (2 weeks); Examinations and special topics (2 weeks)

Prerequisite: ME 212 (grade C- or better)

**ME 716 Intro to Surface & Interface Science**

The first segment of the course is devoted to understanding interfacial phenomena by examining the roles of surface composition and surface texture. The second segment covers how this fundamental understanding can be used to design bio-inspired surfaces for self-cleaning mechanisms, anti-reflective coating, fog harvesting and de-icing.

**Topics:** Theory of capillarity, and the equation of Young and Laplace (2 weeks); Surface and interfacial energy and kinetics of wetting (2 weeks); Thermodynamics of interfaces and Gibbs free energy (2 weeks); Adsorption and Langmuir isotherm (2 weeks); Surface modification and characterization (2 weeks); Electrowetting and electric double layer (1 week); Recent development of bio-inspired surfaces with special wettability (4 weeks)

Prerequisite: ME 212 or physical chemistry or equivalent.

**ME 722 Modeling Dynamics Mech Systems**

Modeling, analysis and simulation of dynamic mechanical systems. Emphasis on the analysis of kinematics and dynamics of rigid mechanical multibody systems undergoing large overall motion using interactive computer simulation programs. Applications to the design and control of dynamic systems such as robots, machine tools, and artificial limbs.

**Topics:** Modeling and Simulation Techniques (2 weeks); Foundations (3 weeks): Virtual prototyping process, parts, initial conditions, constraints, rotation, joints, measures, forces, moments, torques, bushings, impact, scripts, solver, sensors, quiver plots, splines, and design studies; Applications (6 weeks): Falling stone, inclined plane, lift mechanism, pendulum, projectile motion, spring damper, suspension system, four bar linkage, cam-follower, crank slider, controls, valve-train, cam-rocker-valve, stamping mechanism, robot arm, optimization, and airplane control surface; Term Project (3 weeks); Examinations (1 weeks)

Prerequisite: ME 320

**ME 736 Catalytic Exhst Aftertrtmnt Mod**

Fundamental concepts behind catalytic exhaust aftertreatment devices for automobiles including both monolithic catalysts and particulate filters. Studies of other catalytic devices intended for applications in the mechanical and chemical engineering fields. Topics covered are the development of governing equations based on conservation laws and their numerical solutions using finite difference methods. Studies will include a monolithic catalyst. Project assignments will be included.

**Topics:** Primary pollutants, secondary pollutants, greenhouse gases, and regulatory efforts (2 weeks); Introduction to catalytic aftertreatment devices and particulate filters (2 weeks); Fundamentals of chemistry including chemical bonds, chemical kinetics, reaction rates, surface adsorption, equilibrium, and detailed and global reactions (3 weeks); Derivation of the differential versions of the conservation of mass, momentum, energy, entropy, and species, including simplifications and extensions (3 weeks); One-dimensional and one+one-dimensional monolithic catalyst modeling, dynamically incompressible and compressible versions (2 weeks); Student presentations (2 weeks)

Prerequisite: ME 212 with a grade of C- or better and ME 510

**ME 754 Medical Imaging**

This course will focus on the fundamental physics of modern medical imaging technologies, which includes X-Ray, Computed Tomography, Magnetic Resonance Imaging, ultrasound imaging, optical imaging, and more. Recent trends in medical imaging technology development will also be introduced.

**Topics:** Background of biomedical optics (1 week); Single scattering (1 week); Monte Carlo modeling (4 weeks); Convolution for broad-beam response (1 week); Radiative transfer equation and diffusion theory (2 weeks); Hydride model of Monte Carlo method and diffusion theory (1 week); Sensing of optical properties and spectroscopy (1 week); Ballistic imaging and microscopy (1 week); Diffuse optical tomography (1 week); Photoacoustic imaging (1 week); Examination (1 week)

Prerequisite: ME 508

**ME 765 Biomaterials**

An introductory course on biomaterials science and consideration of biomaterials in the design of biomedical implants. Topics including ethical considerations in biomaterials research and the role of the FDA in medical device design are also presented.

**Topics:** Technical Writing (2 weeks); Economic Analysis (0.5 week); Ethics (0.5 week); Research Design (3 weeks); Regulatory (0.5 week); Biomaterials (7 weeks); Oral Communication (0.5 week); Examinations (1 week)

Prerequisite: ME 306

**ME 789 Energy Storage Systems & Control**

This course offers an introduction to the mechanisms, modeling, monitoring and control of energy storage systems with a primary focus on batteries but includes coverage of fuel cells and ultra-capacitors. A major theme is to offer students state-of-the-art knowledge of energy storage systems and aid them in developing the ability to apply estimation and control theory in order to address the problems arising in energy storage management.

**Topics:** After completion of the course, a student is expected to: 1) understand the respective work mechanisms, advantages and disadvantages of batteries, fuel cells and ultra-capacitors, 2) understand the mathematical modeling methodologies for batteries, 3) understand the key estimation/control methods and tools, and 4) build effective solutions for energy storage management problems leveraged with estimation/control theory.

Prerequisite: ME 682

**ME 790 Mechanical Metallurgy**

This course will present an area of knowledge which deals with the behavior and response of metals to applied forces. This knowledge will be presented in four parts: 1) Mechanical fundamentals; 2) Metallurgical fundamentals; 3) Applications in materials testing; 4) Plastic forming of metals.

**Topics:** Mechanical Fundamentalssuch as stress and strain relationships for elastic behavior and an introduction to elements of the theory of plasticity (2 weeks); Metallurgical Fundamentals such as plastic deformation, dislocation theory, strengthening mechanisms, fracture (3 weeks); Applications in materials testing such as Tension Test, Torsion Test, Hardness Test, Fracture Mechanics, Fatigue, Brittle fracture and impact testing (3 weeks); Plastic forming of metals such as Fundamental of metalworking, Forging, Rolling of metals, Drawing of rods, wires and tubes, Sheet-Metal forming (3 weeks); Literature reviews and case studies (3 weeks); Exams (1 week).

Prerequisite: ME 306 and ME 311; Corequisite: ME 307

**Spring 2025**

**ME 608/708 Intro to Mechatronics / Mechatronics**

Undergrads should enroll to ME 608. Graduate students should enroll to ME 708. If you are an undergraduate who would like to take ME 708 instead for an honors class, please email Dr. Wilson for permission. sewilson@ku.edu

Design and implementation of interfaces of microcomputers to mechanical equipment. Includes laboratory experiments presenting selected industrial applications. Emphasis on human factors, functional design parameters and microprocessor interfaces. Includes instruction concerning specifications of practical hardware configurations and writing of programs necessary to accomplish mechanical systems applications.

**Topics:** C++ programming of microcontrollers (4 weeks); Sensors and actuators (3 weeks); Robotic system integration and programming (3 weeks); Modeling and design of mechatronic systems (3 weeks); Individual projects (2 weeks)

Prerequisite: ME 208 and ME 320

**ME 696 Design for Manufacturability**

Tools to incorporate manufacturing and life-cycle concerns into the design of products.

**Topics:** Design process and concurrent engineering (2 weeks); Quality function deployment (1 week); Embodiment and parametric design (1 week); Modeling and prototyping (1 week); Manufacturing process in design (1 weeks); Design for assembly (1 week); Quality engineering (SPC) (2 weeks); Statistics and statistical tolerancing (2 weeks); Design of experiments (Taguchi method) (1 week); Current topics related to manufacturing and engineering (2 weeks); Examinations (1 week)

Prerequisite: ME 501

**ME 750 Biomechanics of Human Motion**

Fundamental concepts of anatomy and physiology are introduced but the focus is on the biomechanics of human motion. Human body segment kinematics and joint kinematics are analyzed. An introduction to muscle mechanics is provided. Applications in balance and gait are covered.

**Topics:** Introduction to Musculoskeletal Modeling and Analysis (1 week); Defining Skeletal Kinematics (10 weeks); Dynamic Equations of Motion (Kane’s Method) (4 weeks)

Prerequisite: ME 320

**ME 752 Acoustics**

This course will teach the production, propagation, and effects of sound waves. Detailed topics include plane wave, spherical wave, and cylindrical wave propagation in free space and waveguides, wave reflection and transmission on an interface, piston radiation, wave scattering and diffraction.

**Topics:** Wave equation (1 week); Plane waves (1 week); Reflection and transmission (3 weeks); Waveguides (1 week); Absorption and dispersion (1 week); Spherical waves (2 weeks); Cylindrical waves (1 week); Radiation (2 weeks); Scattering and diffraction (1 week); Examination and special talk (3 weeks)

Prerequisite: ME 320

**ME 755 Computer Simulation in Biomechanics**

Provides an in-depth knowledge of 1) the process of developing a research question to be addressed with computer simulation, 2) various techniques for medical imaging to obtain model geometries (including hands-on experience with low-field MR imaging), 3) image segmentation techniques, 4) issues affecting geometric accuracy in model building, 5) the determination and specification of loading and/or kinematic boundary conditions, 6) the interpretation of model results in the context of the model limitations and the medical application. Knowledge and/or experience with finite elements is desirable, but not required.

**Topics:** Developing a research question & an appropriate simulation technique (2 Weeks); Medical imaging techniques (2 Weeks); Image theory and segmentation (2 Weeks); Overview of Continuum Mechanics (2 Weeks); Finite Element Theory (2 Weeks); Finite Element Mesh Generation (1 Week); Boundary conditions for models, including kinematic descriptions (2 Weeks); Finite Element Modeling (2 Weeks); Student project presentations (1 Week)

Prerequisite: ME 311 and ME 320 or equivalent.

**ME 760 Biomedical Product Development**

Introduction to methods of taking medical product inventions from conception to initial stage production. Students work in cross-functional teams to investigate development potential of inventions. Topics covered include product development processes, regulatory issues with the FDA, quality system requirements, SBIR/STTR funding pathways, biomaterial and biomechanics issues in medical product design, and ethical considerations.

**Topics:** Technical Writing (2 weeks); Economic Analysis (2 weeks); Ethics (1 week); Research Design (3.5 weeks)

Intellectual Property (1 week); Regulatory (1 week); Quality Systems (1 week); Product Design (2 weeks); Biomaterials and Biomechanics (1 week); Examinations (0.5 weeks)

Prerequisite: Senior or graduate student standing in engineering, business, industrial design, or an applicable life science field.

**ME 790 Advanced Heat and Mass Transfer**

Conduction, convection, and radiation are covered in more detail relative to ME 612, with a focus on the underlying physical phenomena and associated mathematical analyses. Diffusive and convective mass transfer is a significant part of this class, with emphasis on the analogies between conduction heat transfer and diffusive mass transfer, as well as convection heat transfer and convection mass transfer.

Prerequisite: ME 612

**ME 797 Materials for Energy Applications**

Focus on fundamentals of materials for energy applications.

**Topics:** Introduction to material science & engineering and electrochemical technologies; microscopic view of solid materials; mass transfer by migration and diffusion; energy related materials and devices; electrochemical engineering fundamentals

Prerequisite: ME 212

**ME 722 Syllabus Excerpt**

**Textbook:** Mastering Simulink, Dabney and Harman, ISBN 0-13-142477-7 (2003 or newer)

ADAMS (Automatic Dynamic Analysis of Mechanical Systems) materials are provided via Canvas:

• ADAMS Tutorial Kit 2nd Ed

Optional: Computer-Aided Kinematics and Dynamics of Mechanical Systems, Vol I: Basic Methods, Edward J. Haug, ISBN 0-205-11669-8 (out of print)

**Software:** MATLAB 2022 and Simulink.

 ADAMS 2022, MSC Software Corporation, http://www.mscsoftware.com/products/products.cfm

 Free ADAMS Student edition.

**Homework:** Homework, projects, and assignments will be submitted on a regular basis via Canvas on or before the due date. Please check the Canvas Course Calendar to stay on top of due dates.

The completion of each assigned ADAMS workshop will be documented on Canvas using the honors system (see table below).

3 points Example Completed as assigned.

0 points Example not completed as assigned.

**NO LATE HOMEWORK WILL BE ACCEPTED.**

**Collaboration:** Homework, projects, and laboratories are a learning opportunity. Discussion and the exchange of ideas are important parts of the learning process, and such activities are encouraged in a community of scholars. However, you must ensure that any work you submit for grading is your own. You are allowed and encouraged to discuss the methods used to solve the homework with others with the goal of developing a better understanding of the concepts needed to do the homework. Copying the results of others work on assignments or exams will at the very least, result in zeroes assigned to ALL involved. It is the School of Engineering's policy to remove students from the School who copy an exam or to expel them from the university. Copying or deleting unauthorized disk files will have the same effect. Logging onto somebody else's account is not permitted. Students are expected to answer questions regarding any of the work they hand-in.

**Term Project:** A required term project will be developed and completed by the end of the course. See “Term Project” for details. Deliverables will be handed in according to the schedule.

**Tests/Final:** Two tests, each with an in-class section and a take-home section, will provide the student with the opportunity to demonstrate his/her understanding of modeling dynamics of mechanical systems as covered in the course materials. No Final Exam is planned.

**Grading:** Example Workshops 10 %

 Homework, assignments, projects 30 %

 2 Tests (20% each) 40 %

 Term Project 20 %

 Total: 100 %

**ME 750 Syllabus Excerpt**

**Textbook:** GT Yamaguchi, (2006), Dynamic Modeling of Musculoskeletal Motion, A Vectorized Approach for Biomechanical Analysis in Three Dimensions, Springer.

**Useful references:**

• TR Kane and DA Levinson, (1985), Dynamics: Theory and Applications, McGraw-Hill.

• Vaughan, Davis, O'Connor, Dynamics of Human Gait, 2nd Ed, (www.kiboho.co.za/GaitCD)

• BM Nigg and W Herzog, (2007), Biomechanics of the Musculo-skeletal System, 3nd Ed, Wiley.

• Zatsiorsky, (1998), Kinematics of Human Motion, Human Kinetics.

• Whittle, (1996), Gait Analysis, 2nd Ed, Butterworth Heinemann.

• P Allard, I Stokes, J-P Blanchi, Editors, (1995), Three-Dimensional Analysis of Human Movement, Human Kinetics.

• TA McMahon, (1984) Muscles, Reflexes, and Locomotion, Princeton University Press.

• D Winter, (2004) Biomechanics and Motor Control of Human Movement, 3rd ed, Wiley.

• JM Winters, S L-Y Woo, (1990) Multiple Muscle Systems, Springer-Verlag.

**Software:** MATLAB 2022 and LiveScript Symbolic Algebra toolbox

**Homework:** Both chapter homework problems and MATLAB assignments will be required. Homework problems will be handed in at the beginning of the class or submitted via Canvas on or before the due date.

**NO LATE HOMEWORK WILL BE ACCEPTED.**

**Collaboration:** Homework, projects, and active learning activities are learning opportunities. Discussion and the exchange of ideas are important parts of the learning process, and such activities are encouraged in a community of scholars. However, you must ensure that any work you submit for grading is your own work. You are allowed and encouraged to discuss the methods used to solve the homework with others with the goal of developing a better understanding of the concepts needed to do the homework. Copying the results of others work on assignments or exams will at the very least, result in zeroes assigned to ALL involved. It is the School of Engineering's policy to remove students from the School who copy an exam or to expel them from the university. Copying or deleting unauthorized disk files will have the same effect. Logging onto somebody else's account is not permitted. Students are expected to answer questions regarding any of the work they hand-in.

**Term Project:** One Term Project is planned for this class.

**Tests/Final:** Two in-class tests of equal value are scheduled, which will be open book and open notes. No Final exam is planned.

**Grading:** Chapter HW + Grader Assignments 25%

 Application HW 1 & 2 (15% each) 30%

 2 Tests (20% each) 30%

 TP Ch6 Project 15%

 Total: 100%

**Other:** There is no ideal textbook for the course. The required textbook covers a significant portion of the material. The rest will be presented in lecture and/or in handouts. Since there is not yet a course pack containing papers, figures, and summaries, it is important to either attend lecture or to know someone who will. A spirit of cooperation is encouraged.