Senior Specialization – Technical Electives Categorization

- The Mechanical Engineering department offers several technical elective courses in different areas of study, such as aerospace, automotive engineering, biomedical engineering and more.
- Students are able to choose courses in different areas of study to enhance knowledge and gain further understanding in whichever area(s) chosen.

Aerospace
MECH 424 – Advanced Dynamics
MECH 460 – Aeronautics
MECH 468 – Space Propulsion and Power Engineering
MECH 539 – Advanced Fluid Mechanics
MECH 558 – Combustion
MECH 567 – Broad-Beam Ion Sources

Automotive Engineering
MECH 437 – Internal Combustion Engines
MECH 523 – Vehicle Energy Storage System Design
MECH 526 – Fundamentals of Vehicle Dynamics
MECH 527 – Hybrid Electric Vehicle Powertrains
MECH 558 – Combustion

Biomedical Engineering
MECH 470 – Biomedical Engineering
MECH 525 – Cell and Tissue Engineering
MECH 543 – Biofluid Mechanics
MECH 570 – Bioengineering
MECH 573 – Structure and Function of Biomaterials
MECH 574 – Bio-Inspired Surfaces
MECH 576 – Quantitative Systems Physiology
MECH 578 – Musculoskeletal Biosolid Mechanics

Energy Engineering
MECH 303 – Energy Engineering
MECH 463 – Building Energy Systems
MECH 468 – Space Propulsion and Power Engineering
MECH 505 – Steam Power Plants
MECH 523 – Vehicle Energy Storage System Design
MECH 557 – Turbomachinery
MECH 558 – Combustion
MECH 575 – Solar and Alternative Energies
MECH 580A8 – Transportation, Energy, and the Environment

Material Science and Manufacturing
MECH 411 – Manufacturing Engineering
MECH 432 – Metals and Alloys
MECH 432 – Engineering of Nanomaterials
MECH 502 – Advanced/Additive Manufacturing Engineering
MECH 530 – Advanced Composite Materials
MECH 531 – Materials Engineering
MECH 532 – Materials Issues in Mechanical Design
MECH 533 – Composites Product Development
MECH 573 – Structure and Function of Biomaterials
MECH 574 – Bio-Inspired Surfaces
Robotics and Controls
MECH 417 – Control Systems
MECH 529 – Advanced Mechanical Systems
MECH 564 – Fundamentals of Robot Mechanics and Controls
MECH 569 – Micro-Electromechanical Devices

Simulation and Modeling
MECH 513 – Simulation Modeling and Experimentation
MECH 520 – Finite Element Analysis in Mechanical Engineering
MECH 529 – Advanced Mechanical Systems
MECH 552 – Applied Computational Fluid Dynamics
MECH 568 – Computational Methods for Mechanical Engineering

Dynamic Systems
MECH 424 – Advanced Dynamics
MECH 425 – Mechanical Engineering Vibrations
MECH 515 – Advanced Topics in Mechanical Vibrations
MECH 524 – Principles of Dynamics
MECH 526 – Fundamentals of Vehicle Dynamics
MECH 529 – Advanced Mechanical Systems

Systems Engineering and Engineering Economics
MECH 408 – Applied Engineering Economy: Application to Energy and the Environment
MECH 511 – Engineering Decision Making Under Uncertainty
MECH 512 – Reliability Engineering

Thermal and Physical Sciences
MECH 407 – Laser Applications in Mechanical Engineering
MECH 437 – Internal Combustion Engines
MECH 507 – Laser diagnostics for Thermosciences
MECH 538 – Mechanical Engineering Thermodynamics
MECH 539 – Advanced Fluid Mechanics
MECH 543 – Biofluid Mechanics
MECH 544 – Advanced Heat Transfer
MECH 551 – Physics Gas Dynamics I
MECH 567 – Broad-Beam Ion Sources
MECH 577 – Aerosol Physics and Technology
Senior Specialization – Technical Electives

- Nine credits of technical electives are required. At least two courses must be ‘MECH’ technical electives (prefix MECH). The third course may be selected from any of the MECH, Restricted MECH, Alternate, or Restricted Alternate Technical Elective categories.
- 500-level courses require a minimum cumulative GPA of 3.0 or instructor approval.
- Please note that ‘Potential Term Offered’ is subject to change.

**MECH Technical Electives:**

**MECH 303 – Energy Engineering**

- **Credit:** 3 credits
- **Potential Term Offered:** Fall
- **Prerequisite:** MECH237 or MECH337 or CBE310 or ECE341 or PH361
- **Description:** Covers a variety of renewable energy technologies. The class uses foundational heat and mass and fluids to evaluate and understand various renewable energy technologies. Course topics include, solar energy, solar PV, hydro, wind, biofuels, among other energy generation technologies. To provide students an appreciation for the need and promise of simultaneously renewable, alternative, and “clean” energy technologies.

**MECH 407 – Laser Applications in Mechanical Engineering**

- **Credit:** 3 credits
- **Potential Term Offered:** Fall
- **Prerequisite:** PH142
- **Description:** Optical systems are finding increased use in a range of application areas within mechanical engineering; for example, for mechanical measurement, gas-phase measurements and diagnostics, communications and material processing. The main goals of the course are to introduce students to light and optics in a way that allows them to understand engineering application, and to provide students with an overview of the use of optics in a range of applications. The introductory part of the course provides background in the fundamentals of optics and discusses relevant optical sources and equipment (including lasers), while the latter part of the course presents a survey of optical application areas (listed above). Where possible, optical systems and approaches will be compared to conventional ones.

**MECH 408 – Applied Engineering Economy: Application to Energy & the Environment**

- **Credit:** 3 credits
- **Potential Term Offered:** Spring
- **Prerequisite:** MATH161
- **Description:** In this course, students will learn and apply engineering economics principles to understand how individuals, firms and governments evaluate, justify and make decisions, particularly in the arena of energy and the environment. Engineering economics employs mathematical techniques to evaluate the economic outcomes from a host of possible choices thereby providing a basis for rational decision-making. While the course title has the word “engineering” in it, the principles covered in this course comprise a toolset applicable to personal and public policy choices as well as engineering ones. *(Sections may be offered: Online).*

**MECH 411 – Manufacturing Engineering (Online only)**

- **Credit:** 3 credits
- **Potential Term Offered:** Spring
- **Prerequisite:** CIVE360 & MECH331
- **Description:** Casting, forming, machining and welding processes used in manufacturing with emphasis on materials aspects. Introduction to the basic processes listed, how to best utilize the various techniques available, and how the properties of materials effect manufacturability. The course balances the fundamental aspects of materials processing with descriptive content regarding traditional forms of manufacturing.

**MECH 417 – Control Systems**

- **Credit:** 3 credits
- **Potential Term Offered:** Fall
- **Prerequisite:** MATH340 & MECH307
- **Description:** Feedback and forward loop control design and simulation; discrete time and frequency domain methods with implementation considerations. *(Must register for lecture and laboratory).*

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*Course Learning Objectives:*
1. Become more comfortable modeling and analyzing mechanical and electrical systems.
2. Develop more complete understanding of time and frequency system response analysis.
3. Learn how to analyze and design control systems.
4. Develop an understanding of and intuition for PID control.
5. Become proficient with the basics of MatLab and Simulink.
6. Develop interest in pursuing further study in the area of controls.

MECH 424 – Advanced Dynamics

*Potential Term Offered: Spring*

*Prerequisite: MECH324*

*Description:* Dynamics is a very important aspect of mechanical engineering since it is the basis of so many areas (mechanisms, robotics, controls, solid mechanics, fluid mechanics, etc.). Therefore, it is important to be strong in dynamics as a mechanical engineer. MECH424 reviews basic kinematics and dynamics at an advanced level, explores 3-D mechanics and gyroscopic motion, and focuses on Lagrange energy methods for analyzing dynamics problems. The course is taught by Dr. Dave (his favorite to teach), and the class size is usually small. (*More information is available at http://www.engr.colostate.edu/~dga/mech424/*)

MECH 425 – Mechanical Engineering Vibrations

*Potential Term Offered: Fall*

*Prerequisite: MECH324*

*Description:* Vibrations applied to rotating machinery and structures. SDOF and MDOF systems, mode shapes, vibration measurements and control. (*Hands-on lab*).

MECH 431 – Metals and Alloys

*Potential Term Offered: Fall*

*Prerequisite: MECH331*

*Description:* Engineering metals and alloys, modification of properties by alloying, plastic deformation, and heat treatment. Fundamentals of physical metallurgy.

MECH 432 – Engineering of Nanomaterials

*Potential Term Offered: Fall (even years)*

*Prerequisite: MECH331*

*Description:* Structure, properties, and processing of extremely small (10 to the minus 9 m) synthetic and natural materials.

MECH 437 – Internal Combustion Engines

*Potential Term Offered: Fall*

*Prerequisite: MECH344*

*Description:* The purpose of the course is to apply the principles of thermodynamics, fluid mechanics, and heat transfer to better understand the behavior of internal combustion engines. The course will develop various thermodynamic cycles, analytical models of the combustion processes for spark and compression ignition engines, and the fluid flow associated with the intake, in-cylinder, and exhaust flow. Emissions, friction and heat transfer in engines will also be addressed. The course will include the use of MATLAB programs to model engine performance.

*Course Learning Objectives:*

1. Develop models of the overall performance characteristics of internal combustion engines.
2. Use thermodynamic analysis to predict engine performance, including finite heat release, fuel-air chemistry, and combustion analysis.
3. Analyze the fluid flow, heat transfer, and friction in components of internal combustion engines

MECH 460 – Aeronautics

*Potential Term Offered: Spring*

*Prerequisite: MECH342*

*Description:* Thermodynamics and fluid mechanics principles applied to the mechanics, aerodynamics, performance, stability, and control of airplanes.

*Course Learning Objectives:*
Upon successful completion of this course, students should be able to
• calculate airplane aerodynamics including lift and drag,
• calculate airplane performance including maximum velocity, range and endurance, take-off and landing,
• calculate airplane stability and control, and
• calculate airplane propulsion (propeller, jet, and rocket)

MECH 463 – Building Energy Systems
3 credits
Potential Term Offered: Spring
Prerequisite: MECH344
Description: Comfort, psychometrics, loads, solar radiation, heating and cooling system design, transport, solar system design, economics.

Course Learning Objectives:
1. To learn how to apply the fundamentals of thermal sciences (heat transfer, thermodynamics, fluid mechanics) to determine the environmental performance of buildings.
2. To learn how to model and compute building heating and cooling loads.
3. To learn how to calculate the performance of building HVAC equipment such as fans, diffusers, heat exchangers, and chillers/compressors.

MECH 468 – Space Propulsion and Power Engineering
3 credits
Potential Term Offered: Fall
Prerequisite: ECE204, MECH337, & MECH342
Description: Orbital mechanics and space missions; chemical, nuclear, and electric rockets; nuclear heat sources; thermoelectric and photovoltaic devices.

MECH 470 – Biomedical Engineering
3 credits
Potential Term Offered: Fall
Prerequisite: MATH155 or MATH160 & PH141
Description: Engineering application in human/animal physiology, diagnosis of disease, treatment, rehabilitation, human genome manipulation.

Restricted MECH (Minimum cumulative GPA of 3.0 is required or instructor approval):

MECH 502 – Advanced/Additive Manufacturing Engineering
3 credits
Potential Term Offered: Spring
Prerequisite: MECH202 & MECH331
Description: In this course, you will learn the importance of additive manufacturing (a.k.a. 3D Printing) and its huge role in global product development and innovation. You will develop a rich knowledge of 3D printing technologies, devices, capabilities, materials and applications. You will learn the trade-offs between various 3D printing processes and technologies, along with the various software tools, processes and techniques enabling personal fabrication, such as 3D scanning. You will explore the broad range of 3D printing applications, including biomedical, aerospace, consumer products, and creative artistry, to mention a few. Finally, you will learn the latest trends and opportunities in 3D printing, including “personal” 3D printing, localized services, production parts, mass customization, and how to commercialize your ideas. (Sections may be offered: Online).

MECH 505 – Stream Power Plants
3 credits
Potential Term Offered: Spring
Prerequisite: MECH344
Description: Technology review and application of engineering sciences and economics to the analysis and design of vapor power generation systems. Vapor power cycles, steam generation, and auxiliary systems associated with power plants. Overall design of power plants as well as component design. Fossil fuel and nuclear energy systems are considered.

Course Learning Objectives:
1. Apply thermodynamic principles to real-world power generation.
2. Recognize and describe central-power-station equipment.
3. Identify the economic issues of power generation.
4. Demonstrate capability to design and optimize power plant systems.

MECH 507 – Laser Diagnostics for Thermosciences 3 credits
Potential Term Offered: Spring (odd years)
Prerequisite: PH142
Description: Basics of optics, spectroscopy, and lasers. Physics and applications of laser diagnostic techniques used in Thermosciences.

MECH 511 – Engineering Decision Making under Uncertainty (Online only) 3 credits
Potential Term Offered: Spring
Prerequisite: MECH410 & STAT315
Description: You will learn to apply advanced systems engineering and engineering economic methodologies and advanced financial analysis concepts to real world capital allocation decision making in government, the military, and the service and manufacturing industries.

Topics include continuous compounding, capital budgeting models, capital rationing, lending and borrowing, business and engineering measures of worth, costs of delay, multi-criteria optimization, utility theory, risk assessment, risk attitudes, catastrophic business risk (risk of ruin), preference and ordering rules, advanced financial and engineering concepts, certainty equivalence, value determination, value of information, business and Engineering measures of worth, stochastic dominance, portfolio theory, simulation, decision tree analysis, sensitivity analysis, certainty equivalents, and replacement analysis.

MECH 512 – Reliability Engineering (Online only) 3 credits
Potential Term Offered: Fall (even years)
Prerequisite: STAT315 & MECH513
Description: Models to predict time to failure of mechanical or electronic devices, reliability data analysis and case studies. Specific objectives include (1) Gain an introduction to the probabilistic and statistical methods used by engineers in order to gain a competitive edge in industry by improving reliability, (2) Be able to apply methods to product as well as process reliability, and (3) Learn how the mathematical models and results apply to engineering design and the analysis of lifetime data sets within applications drawn from a variety of disciplines.

MECH 513 – Simulation Modeling and Experimentation
Potential Term Offered: Spring
Prerequisite: STAT315
Description: This course will introduce fundamental concepts of integrated modeling, simulation, and experimentation as a component of the systems engineering process. You will learn practical processes for improving the defensibility, cost and capabilities of your simulations. This course places emphases on verification and validation of computational models, on quantification and propagation of uncertainty, on multi-disciplinary analysis and optimization, and on synthesis and decision-making. We will use tools including MATLAB, Excel, ModelCenter, Simulink and SimEvents to model in a variety of engineering applications and domains. With semi-weekly homework and mid-term and final projects, this course will build engineering students’ capabilities to perform scientific and engineering computing for the purposes of design, research and decision support. (Sections may be offered: Online).

MECH 515 – Advanced Topics in Mechanical Vibrations 3 credits
Potential Term Offered: Fall (odd years)
Prerequisite: MECH324
Description: Structural modal analysis, rotor dynamics, and torsional vibrations. Lectures are supported with practical application labs. (Must register for lecture and laboratory).

MECH 520 – Finite Element Analysis in Mechanical Engineering 3 credits
Potential Term Offered: Spring
Prerequisite: CIVE360 & MATH340 or MATH530
Description: Application of FEA as a tool to analyze mechanical engineering problems.

MECH 523 – Vehicle Energy Storage System Design 3 credits
Potential Term Offered: Spring
Prerequisite: MECH331
Description: Develop vehicle system designs utilizing electrochemical energy storage systems such as batteries and capacitors.

MECH 524 – Principles of Dynamics 3 credits
Potential Term Offered: Fall
Prerequisite: MECH324
Description: Reviews basic kinematics and dynamics at a graduate level, explores 3-D mechanics and gyroscopic motion, and focuses on Lagrange energy methods for analyzing dynamics problems. More information is available at http://www.engr.colostate.edu/~dga/mech524.

Course Learning Objectives:
1. Become proficient with applying basic kinematic and dynamic relations.
2. Learn how to use and apply Lagrange's Equations.
3. Learn how to use and apply 3-D rigid body dynamics principles
4. Develop a basic understanding of Euler's Equations and gyroscopic motion.

MECH 525 – Cell and Tissue Engineering 3 credits
Potential Term Offered: Spring (even years)
Prerequisite: BC351 or BMS300 or BMS500 or BZ310 or NB501
Description: This course is designed to familiarize current and future researchers with tissue engineering concepts and current practice. Topics covered include: tissue morphogenesis and homeostasis, stem cells, cell signaling, cell nutrition, cryopreservation, biomaterials, tissue engineering scaffolds, biocompatibility and ethics. (Sections may be offered: Online).

Course Learning Objectives:
Upon the completion of this course, you should be able to:
1. Understand the paradigms of tissue engineering and regenerative medicine.
2. Develop a more complete understanding of cell biology, development and tissue repair. Improve knowledge of mechanical and chemical properties of biomaterials.
3. Develop an understanding of current challenges in the field of tissue engineering.

MECH 526 – Fundamentals of Vehicle Dynamics 3 credits
Potential Term Offered: Spring
Prerequisite: MECH324
Description: Kinetics of vehicle suspensions, steady state and transient stability and control, tires, wheel and suspension geometry and loads, dampers, steering.

MECH 527 – Hybrid Electric Vehicle Powertrains 3 credits
Potential Term Offered: Fall
Prerequisite: MECH307
Description: The purpose of this course is to introduce students to the engineering design and analysis of hybrid electric vehicle (HEV) powertrains. Internal combustion engines have been the prime mover of choice in automobiles for over a century. Increasingly stringent limits on emissions, as well as attention to conservation of hydrocarbon fuels is driving the development of alternative power sources for vehicles, with hybrid-electric powered vehicles rapidly developing as a viable solution. The course is interdisciplinary between ME and ECE – a natural consequence of the technological integration of electrical and mechanical systems inherent in hybrid powertrains; however, students are not expected to have expertise in electrical or mechanical systems.

MECH 529 – Advanced Mechanical Systems (Online only) 3 credits
Potential Term Offered: Fall
Prerequisite: MECH307
Description: Modeling, analysis, and synthesis of practical mechanical devices in which dynamic response is dominant consideration.

MECH 530 – Advances Composite Materials 3 credits
Potential Term Offered: Fall  
Prerequisites: CIVE360 & MECH331  
Description: Introduction to Advanced Composite Materials is intended to introduce composite constituent materials, such as fibers and matrices, discuss their development, and investigate the interactions, which yield the synergy that is the basis for the technical interest in advanced fiber reinforced composites. Further, the course introduces concepts of a designed or tailored material, focusing on microstructural tailoring aspects of anisotropic materials which can allow variations in the elastic modulus and the strength of composite materials. Some background in such advanced materials gives the mechanical designer new tools with which to complete a given project and these "designer" materials need to be better understood if optimal application of their properties is to take place.

MECH 531 – Materials Engineering  
Potential Term Offered: Spring  
Prerequisites: MECH331 & MECH431  
Description: Selection of structural engineering materials by properties, processing, and economics; materials for biomedical and biotechnology applications. (Sections may be offered: Online).

MECH 532 – Materials Issues in Mechanical Design  
Potential Term Offered: Fall  
Prerequisite: MECH331  
Description: Failure mechanisms from materials viewpoint with emphasis on use in design. Fracture, creep, fatigue, and corrosion. (Sections may be offered: Online).

MECH 533 – Composites Product Development  
Potential Term Offered: Fall  
Prerequisites: MECH331 & CIVE360  
Description: To introduce students to the practical application of Fiber Reinforced materials in mechanical design. To develop sufficient skills in materials selection, material performance analysis and in manufacturing to enable the student to successfully develop composite components and to fabricate the product. Materials handling and safety are important aspects, as is proper use and maintenance of associated manufacturing equipment. (Must register for lecture and laboratory).

MECH 538 – Mechanical Engineering Thermodynamics  
Potential Term Offered: Fall  
Prerequisite: MECH337  
Description: First and second laws of thermodynamics applied to engineering devices and systems. Introduction to availability, energy, and lost work analysis.

MECH 539 – Advanced Fluid Mechanics  
Potential Term Offered: Fall  
Prerequisite: CIVE300 or MECH342  
Description: Development of the three-dimensional, unsteady, governing equations for describing the motion of inviscid and viscous compressible fluids; differential and integral forms of the equations; constitutive equations for a compressible fluid; the entropy equation; compressible boundary layers; area-averaged equations for one-dimensional steady flow; shock waves; channel flow with heat addition and friction; flow in nozzles and inlets; oblique shock waves; Prandtl-Meyer expansion; unsteady one-dimensional flow; the shock tube; acoustics in one-dimension; steady flow in two-dimensions; potential flow; linearized potential flow; lift and drag of thin airfoils. Upon completion of this course, students will be equipped with theories and analytical methods for furthering studies on compressible flow with more general flow geometry and real gas effects.

MECH 543 – Biofluid Mechanics  
Potential Term Offered: Spring (odd years)  
Prerequisites: MECH342 or CIVE300 or BMS300 & PH121 or BMS300 & PH141 or BMS420  
Description: The course will focus on biotransport concepts for understanding transport in and created by living organs/organisms with a focus on fluid mechanics and cardiovascular flow. Upon completing this course, the students should (1) understand the governing physics of biotransport (2) learn to conduct biofluids research on an interesting problem
and apply engineering fundamentals to contribute to its solution, and (3) learn the fundamentals of interdisciplinary (biology/engineer) work.

**MECH 544 – Advanced Heat Transfer**
3 credits
*Potential Term Offered: Spring*
*Prerequisite: MECH344*
*Description:* The course begins with conduction, defined as the flow of thermal energy through a solid material due to a temperature difference. The thermal energy flow is modeled as a thermal diffusion equation, and representative one-dimensional and two-dimensional analyses for simple planar, cylindrical, and spherical geometries are developed for various spatial and temporal boundary conditions. The middle part of course is concerned with convection, the flow of thermal energy due to the motion of a fluid. Since the flow and heat transfer configurations that can be categorized are very diverse, they are classified into a matrix of external and internal flow, forced and free convection, and laminar and turbulent flow. Again, representative analyses are performed for both simple and more complex geometries and flow fields. The last part of the course is concerned with radiation heat transfer, specifically radiation exchange between surfaces. The importance of emissive power, spectral emissivity and geometry are demonstrated for a variety of engineering problems. Since most engineering devices have thermal energy transport resulting from more than one heat transfer mode, all three modes need to be considered in a comprehensive analysis. There will also be assigned reading of related journal articles during the progression of the course. The computational tools used in this course for the homework assignments will be Excel for most straightforward problems and Matlab/Python/MathCad/EES for more complicated problems.

**MECH 551 – Physical Gas Dynamics I**
3 credits
*Potential Term Offered: Fall (odd years)*
*Prerequisite: MECH342*
*Description:* Characteristics of real gases in reacting and nonequilibrium systems; equilibrium air; statistical mechanics, chemical thermodynamics.

**MECH 552 – Applied Computational Fluid Dynamics**
3 credits
*Potential Term Offered: Fall (odd years)*
*Prerequisite: CIVE300 or CBE331 or MECH342*
*Description:* The course objective is to learn how to use a CFD program (ANSYS Fluent) intelligently to solve fluid related problems accurately. To achieve this objective, you will study:

- Basic theory of CFD,
- Mesh generation techniques,
- Solver settings (boundary condition, discretization schemes, time step in transient, etc.)
- Meanings and choices of physical models such as turbulence and species
- Evaluation of the results of CFD analysis.
- Application of CFD in various areas

**MECH 557 – Turbomachinery**
3 credits
*Potential Term Offered: Spring*
*Prerequisite: MECH337 & MECH342*
*Description:* Application of fundamental principles of thermodynamics and fluid mechanics to turbomachinery.

**MECH 558 – Combustion**
3 credits
*Potential Term Offered: Fall (even years)*
*Prerequisite: MECH342*
*Description:* Combustion processes: explosions, detonations, flame propagation, ignition, generation of pollutants in moving and stationary energy conversion systems.

**MECH 564 – Fundamentals of Robot Mechanics and Controls**
3 credits
*Potential Term Offered: Spring*
*Prerequisite: MECH417*
*Description:* This course will cover basic robot technologies concentrating on the modeling and control of industrial robots (articulated serial manipulators). You will learn how to model the kinematics and dynamics for such robots. Based on the kinematics and dynamics model, you will also learn how to control the robot for precise and fast motion. Other topics such
as vision based control, motion planning, mobile robots etc. will also be presented. You will have the opportunity to simulate and control the motion of an industrial robot for the final project. After this course, you will fully understand how industrial robots work. Knowledge of differential equations, matrices, control system, and computer programming are preferred for this course.

MECH 567 – Broad-Beam Ion Sources  
*Potential Term Offered: Spring (odd years)*  
*Prerequisite: MATH340*  
*Description:* Physical processes in broad-beam electron-bombardment ion sources for space propulsion and ion machining applications.

MECH 568 – Computational Methods for Mechanical Engineering  
*Potential Term Offered: Fall*  
*Prerequisites: MATH450 or MATH451*  
*Description:* Fundamental principles, which provide the foundation for the software and algorithms used in Mechanical Engineering.

MECH 569 – Micro-Electro-Mechanical Devices  
*Potential Term Offered: Spring*  
*Prerequisite: MECH344 with a minimum grade of C or ECE 331 with a minimum grade of C*  
*Description:* This technology combines mechanical and electrical engineering systems on a silicon chip for: Body area networks dedicated sports monitors, medical diagnostics and to monitoring health, instant lab on a chip blood analysis for disease markers, ink jet printing of 3D body parts, human DNA analysis on a chip for under $1000. In addition, pico projection displays now available for augmented reality assistance in medical procedures. Finally, $3 cost for accelerometers, gyroscopes enable hand gestures to be read electronically in order to control medical devices. This course also impacts new microfluidic applications such as: lab on a chip biotechnology to determine blood glucose levels, even DNA, from bodily fluids in real time for again 1/1000 the cost of prior methods allowing personalized medicine, low cost medical diagnostics, and new means of drug delivery, such as insulin, directly to areas of the body using micro fluidic delivery to mention but a few new commercial products. All are systems on chip (SOC) low cost solutions to real problems. It is an exciting time to learn about MEMS, progress to date and future capabilities.

MECH 570 – Bioengineering  
*Potential Term Offered: Spring*  
*Prerequisites: MECH307 & MECH324*  
*Description:* Physiological and medical systems analysis using engineering methods including mechanics, fluid dynamics, control, electronics, and signal processing. *(Sections may be offered: Online).*

MECH 573 – Structure and Function of Biomaterials  
*Potential Term Offered: Spring*  
*Prerequisite: MECH331*  
*Description:* A traditional mechanical engineering approach is used to explore the structure-function relationships of natural biomaterials that is then applied to the analysis of synthetic bio-inspired and biomimetic materials. The main focus is on structure/function relationships of materials. There is also emphasis on mechanical design and function, with some discussion of cellular interactions. Materials covered include skin, horn, nail, hoof, hair, wood, plants, spider silk, nacre, bone, tendon, ligament, cartilage, meniscus, and tissue engineering scaffolds. Topics for bio-inspired and biomimicked materials include structural materials like fiber-reinforced cements and polymers, and biomedical materials for clinical applications.

MECH 574 – Bio-Inspired Surfaces  
*Potential Term Offered: Spring*  
*Prerequisites: MECH342 & CHEM111*  
*Description:* The course will present and analyze the surfaces of a wide range of biological species, including lotus leaves, rose petals, water striders, arctic spring tails, shards, desert beetles, and pitcher plan leaves. Gain the understanding of the unique surface functionality associated with each of these biological species by examining the roles of surface composition and surface texture. Subsequently, we will discuss how this fundamental understanding can be used to design bio-inspired
surfaces for various applications such as spill resistant fabrics, microrobots, stain resistant displays, drag reduction, fog harvesting and de-icing.

**MECH 575 – Solar and Alternative Energies**  
*3 credits*  
*Potential Term Offered: Spring*  
*Prerequisites: MECH337 & MECH342 & MECH344*  
*Description:* First 7 weeks focus on Solar Photovoltaics, which entails the Basics of Solar Energy, Fundamentals of PV, Si Cell Technology, Thin Film PV, Emerging PV Technologies, Characterization and testing, PV system design and economics, PV in Buildings, Economics for on-grid and off-grid systems. Weeks after you will discuss Solar Thermal focusing on flat plate collectors, Solar water heaters, parabolic trough systems, Hybrid solar lighting technologies. Then you will focus on Wind energy, Introduction, Wind characteristics and resources, aerodynamics, mechanics and dynamics, applications. After you will learn about Biofuels and Geothermal.

**MECH 576 – Quantitative Systems Physiology**  
*3 credits*  
*Potential Term Offered: Spring*  
*Prerequisites: BMS300 & CHEM113 & MATH340 & PH142*  
*Description:* The course provides a quantitative understanding of functions of human organs, their interconnections and underlying cellular and molecular aspects that drive such functions. Expand knowledge on research into the health/biomedical-related arenas. (*Sections may be offered: Online*).

**MECH 577 – Aerosol Physics and Technology**  
*3 credits*  
*Potential Term Offered: Spring (odd years)*  
*Prerequisite: PH141*  
*Description:* Aerosols and their applications in science and engineering, air pollution control, atmospheric science, and public health. Topics cover the physical and chemical principles underlying the behavior of particles suspended in air, including particle size, aerodynamics, motion of particles in a force field, particle size statistics, and optical and electrical properties. (*Senior standing. Sections may be offered: Online*).

*Course Learning Objectives:*  
Upon completing this course, students will be able to (1) describe particle properties that are relevant for aerosol behavior and measurement, (2) describe the fundamental forces that govern aerosol transport, (3) employ state-of-the art techniques for aerosol measurement, (4) identify significant gaps in our understanding of aerosol behavior, and (5) communicate their knowledge of aerosol measurement techniques in a concise written format.

**MECH 578 – Musculoskeletal Biosolid Mechanics**  
*3 credits*  
*Potential Term Offered: Fall*  
*Prerequisite: CIVE360*  
*Description:* Application of engineering concepts to quantify the mechanical behavior of load-bearing biological tissues and orthopaedic implant performance.

**MECH 580A8 – Transportation, Energy and the Environment**  
*3 credits*  
*Potential Term Offered: Spring*  
*Prerequisite: MECH337*  
*Description:* The transportation sector roughly accounts for a third of the energy use and nearly a quarter of climate- and health-relevant emissions of greenhouse gases and criteria pollutants in the United States. This class will extensively discuss the energy use and environmental impacts of the transportation sector in the United States. Topics will include vehicle design, dynamics and efficiency; combustion and emission formation; powertrain design, internal combustion engines, fuel cells and batteries; conventional and alternative fuels; travel demand, travel modes, transportation planning, system analysis and land use interactions; life cycle assessment and well-to-wheels analysis.

**MECH580B1 – Industrial Gas and Dual-Fuel Engines**  
*3 credits*  
*Potential Term Offered: Fall*  
*Description:* These engineering marvels of extreme power density, efficiency, and durability are the power of choice for electric power and gas compression. They are also a critical green technology for future petroleum development, petroleum production, rail, mining, and marine applications. Students will gain a strong fundamental understanding of engine
components, thermodynamics, and economics of the industrial engine business from the world leader in industrial natural gas engine technology.

**MECH580B2 – Mechanical Vibrations**  
*Potential Term Offered: Fall*  
*Description:* Students will be able to apply general vibration theory to practical vibration measurement and analysis systems. Specifically, students will be able to compute damping coefficients, natural frequencies and amplitude response in both free and forced vibration conditions. They will be able to compute vibration response in multi-degree of freedom systems including mode shape analysis. They will be able to diagnose vibration response to malfunctions such as mass unbalance and shaft misalignment, gear meshing faults, AC induction motor faults, bearing faults, and unbalanced hydraulic and aerodynamic forces in pumps and fans. Additionally students will learn to control vibration by designing isolation systems, dynamic absorbers, damping treatments, and balance corrections. They will also be introduced to basic rotodynamics concepts.

*Please note that if you do not see a 400-500 level MECH course listed on this sheet and the course is listed on the class schedule, please refer to the course description for information about the course. We recommend you run a Degree Progress Audit after you register to confirm that your course(s) satisfy technical elective requirement(s).*

**Alternate Technical Electives:**

**BIOM 382 – Study Abroad: Prosthetics in Ecuador**  
*Potential Term Offered: Summer International Experience*  
*Description:* Students will design and fabricate prosthetics for under-served populations in Ecuador. Course experience will occur in Quito, Ecuador in partnership with Range of Motion Project (ROMP), a non-profit, for impact healthcare organization. This course provides an opportunity for students to gain international, hands-on experience and to participate in developing solutions for these under-served and high-need populations in Ecuador. The course includes four meetings at CSU prior to the experience, the in-country experience in Ecuador, and students will be required to submit daily journal entries that reflect observations and insights on the culture of innovation in Ecuador. Students registered for 2 credits will also be required to complete reading assignments prior to the experience, and submit a post-experience video reflection presentation and a post-experience project proposal report.

*Course Learning Objectives*  
1. Demonstrate high professional social and ethical standards while examining and addressing the global impact of technology to improve quality of life in society  
2. Provide practical experiences and creativity to solving problems at the interface of engineering and the life sciences, as individuals and team members  
3. Use multidisciplinary backgrounds to foster communication and collaboration  
4. Recognize and expand scope of knowledge, and identify and create professional opportunities.

**BMS 300 – Principles of Human Physiology**  
*Potential Term Offered: Fall, Spring, Summer*  
*Prerequisite:* BZ101 or BZ110 or LIFE102 & CHEM103 or CHEM107 or CHEM111  
*Description:* Physiology of humans.

**CON 450 – Travel Abroad – Sustainable Buildings**  
*Potential Term Offered: January 2-13, 2019*  
*Description:* The course will focus on the main components of sustainable design and construction, energy, healthy buildings, natural resources, and other environmental issues. The participants will gain knowledge of the best sustainable practices through renowned international examples and will execute a short project utilizing those principles.

*Course Learning Objectives*  
1. Define concepts of sustainability and climate adaptive design, development, and construction  
2. Build a cross-disciplinary, cross-cultural, learning environment through student diversity, teamwork, and interdisciplinary project work
3. Complete a sustainably oriented service experience
4. Apply concepts related to human-centered design and sustainability in a tropical climate

**CS 150 – Interactive Programming with Java**  
3 credits  
*Potential Term Offered:* Fall, Spring  
*Prerequisite:* MATH1***to 200  
*Description:* Introduction to object-oriented programming with Java; problem solving, creating applets for Web pages, and graphical user interfaces. (Must register for lecture and recitation).

**CS 155 – Introduction to Unix**  
1 credit  
*Potential Term Offered:* Fall, Spring, Summer  
*Prerequisite:* N/A  
*Description:* Unix shell commands, utilities (editors, sorting, file management), shell scripting.

**CS 156 – Introduction to C Programming I**  
1 credit  
*Potential Term Offered:* Fall, Spring, Summer  
*Prerequisite:* CS155 *(may be taken concurrently)* & MATH118  
*Description:* Basic elements of language structure, data types, expressions, program control flow and modularity.

**CS 157 – Introduction to C Programming II**  
1 credit  
*Potential Term Offered:* Fall, Spring, Summer  
*Prerequisite:* CS156 *(may be taken concurrently)* & MATH118  
*Description:* More basic design types function usage and strings. Arrays, user-defined types and structures, enumerated types, recursion, and dynamic storage allocation.

**CS 163 – Java (CS1) No Prior Programming**  
4 credits  
*Potential Term Offered:* Fall, Spring, Summer  
*Prerequisite:* MATH124 with a minimum grade of C  
*Description:* Computer programming in Java for students without previous programming experience. Topics include variables, assignment, expressions, operators, booleans, conditionals, characters and strings, control loops, arrays, objects and classes, file input/output, interfaces, recursion, lists, and sorting. *(Must register for lecture and laboratory).*

**CS 164 – Java (CS1) Prior Programming**  
4 credits  
*Potential Term Offered:* Fall, Spring  
*Prerequisite:* MATH124 with a minimum grade of C  
*Description:* Computer programming in Java for students with limited programming experience. Problem decomposition for good design; expressions, operators, booleans, conditionals, characters and strings, control loops, arrays, objects and classes, file input/output, interfaces, recursion, lists, and sorting.

**CIVE 367 – Structural Analysis**  
3 credits  
*Potential Term Offered:* Fall, Spring  
*Prerequisite:* CIVE360  
*Description:* Determination of actions in and deformations of determinate and indeterminate structures.

**CIVE 438 – Environmental Engineering Concepts**  
3 credits  
*Potential Term Offered:* Fall, Spring  
*Prerequisite:* CHEM113 & CIVE300 or CBE331 or MECH342  
*Description:* Environmental engineering approaches to designing water supply, wastewater removal, and pollution control systems.

**ECE 411 – Control Systems**  
4 credits  
*Potential Term Offered:* Fall  
*Prerequisite:* ECE312 with a minimum grade of C
Control system analysis and design for linear systems: stability and performance; time and frequency domain techniques. (Must register for lecture and laboratory).

ECE 465 – Electrical Energy Generation Technologies 3 credits
Potential Term Offered: Spring
Prerequisite: ECE202 with a minimum grade of C
Description: Various electrical energy generation alternatives. Comparisons based on cost, reliability, availability and environmental impact.

ENGR 422 – Technology Entrepreneurship 3 credits
Potential Term Offered: Spring
Prerequisites: MGT 340 or permission of instructor
Description: The course introduces students to the tenets of technology-based entrepreneurship and teaches them to recognize, analyze, and act on opportunities. Students will complete a semester-long opportunity analysis of their own original intellectual property or intellectual property provided by a faculty member or CSU Ventures. This course qualifies as one of the 4 classes required for the Entrepreneurship Certificate. Engineering students can obtain an Entrepreneurship Certificate by taking MGT 340, ENGR 422 and two semesters of Senior Capstone Design.

HES 207 – Anatomical Kinesiology 3 credits
Potential Term Offered: Fall, Spring, Summer
Prerequisite: MATH125 (may be taken concurrently)
Description: Anatomical, physiological, and mechanical fundamentals of human movement.

MATH 331 – Introduction to Mathematical Modeling 3 credits
Potential Term Offered: Fall
Prerequisite: MATH161 (may be taken concurrently) & MATH229 (may be taken concurrently) or MATH369 (may be taken concurrently)

MATH 332 – Partial Differential Equations 3 credits
Potential Term Offered: Spring
Prerequisite: MATH 340 or MATH345
Description: Partial differential equations, separation of variables, Fourier series and transforms, Laplace, heat and wave equations.

MATH 369 – Linear Algebra I 3 credits
Potential Term Offered: Fall, Spring, Summer
Prerequisite: MATH161 or MATH255 or MATH271
Description: Linear systems, matrices, subspaces of Euclidean spaces, linear transformations on Euclidean spaces, eigenvalues, and eigenvectors.

MGT 305 – Fundamentals of Management 3 credits
Potential Term Offered: Fall, Spring, Summer
Prerequisite: N/A
Description: Managerial process of planning, directing, and controlling inputs of an organization. Analysis, decision-making, and survey of research literature.

MGT 340 – Fundamentals of Entrepreneurship 3 credits
Potential Term Offered: Fall, Spring, Summer
Prerequisite: N/A
Description: Concepts of entrepreneurship and role of entrepreneurs in the economy.

MKT 305 – Fundamentals of Marketing 3 credits
Potential Term Offered: Fall, Spring, Summer
Prerequisites: AREC202 or ECON101 or ECON202

Description: Overview of marketing activities involved in provision of products and services to consumers, including target markets and managerial aspects.

**PH 314 – Introduction to Modern Physics**
**Potential Term Offered:** Spring
**Prerequisites:** MATH261 (may be taken concurrently) & PH142
**Description:** Relativity; quantum mechanics; atomic structure; applications to solid-state, nuclear, and elementary particle physics.

**PH 341 – Mechanics**
**Potential Term Offered:** Fall
**Prerequisites:** MATH340 or MATH345 & PH142
**Description:** Particle dynamics, translation and rotation of rigid bodies, moving coordinate systems, Lagrangian mechanics, matrix and tensor methods.

**PH 353 – Optics and Waves**
**Potential Term Offered:** Fall
**Prerequisites:** MATH261 & PH142
**Description:** Geometrical optics; wave optics; interference, diffraction, and polarization; quantum optics.

**PH 451 – Introductory Quantum Mechanics I**
**Potential Term Offered:** Fall
**Prerequisite:** MATH340 or MATH345 & PH314
**Description:** Schrodinger's theory of wave mechanics, potential wells, harmonic oscillators, wave packets, operators, angular momentum.

**Restricted Alternate (Minimum cumulative GPA of 3.0 is required):**
**ENGR/ECE 501 – Foundations of Systems Engineering**
**Potential Term Offered:** Fall, Spring
**Prerequisite:** N/A
**Description:** Functional components of systems engineering, application of systems engineering to practical problems, system life-cycle process. *(Sections may be offered: Online)*

**CIVE 504 – Wind Engineering**
**Potential Term Offered:** Fall
**Prerequisite:** CIVE360
**Description:** Influence of wind on humanity. Applications to structures, air pollution, wind energy, agricultural aerodynamics, snow movement, human comfort. *(Sections may be offered: Online).*

**CIVE 560 – Advanced Mechanics of Materials**
**Potential Term Offered:** Fall
**Prerequisite:** CIVE360
**Description:** Analysis of stress and strain failure theory; selected topics in solid mechanics, plate analysis; introduction to elastic stability. *(Sections may be offered: Online).*

**CIVE 562 – Fundamentals of Vibrations**
**Potential Term Offered:** Spring
**Prerequisite:** CIVE261 & CIVE360
**Description:** Free and forced vibrations of single, two, and multiple degree of freedom systems. Closed-form and numerical solutions. *(Sections may be offered: Online).*

**Other Interesting Courses**
**ENGR 300 – 3D Printing Lab for Engineers**
**Potential Term Offered:** Fall, Spring
Prerequisite: BIOM 101 or CBE 101 or CIVE 102 or ECE 102 or ENGR 101 or MECH 103.

Description: Basics of 3D printing, technology, workflows, techniques and related software, focused on practical usage and project development in engineering. Topics include technology of devices, usage, calibration and tuning, repair and maintenance, and techniques for maximizing part quality with minimal waste. Course lectures are conducted online. Students will utilize the 3D printing lab to complete a semester project. For more information, click here.

**This course will not fulfill a MECH Technical Elective or an Alternate Technical Elective requirement.**