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.
Senior Specialization – Technical Electives

- Twelve credits of technical electives are required. At least three courses must be ‘MECH’ technical electives (prefix MECH). The fourth 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.
- Delivery Method is not guaranteed in context listed.

MECH Technical Electives:

**MECH 403 – Energy Engineering**
- **Delivery Method:** On-campus
- **Potential Term Offered:** Fall
- **Prerequisite:** MECH 237 or MECH 337 or CBE 310 or ECE 341 or PH 361
- **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.
- **Sections may be offered:** Online.

**MECH 407 – Laser Applications in Mechanical Engineering**
- **Delivery Method:** On-campus
- **Potential Term Offered:** Fall
- **Prerequisite:** PH 142
- **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.
- **Sections may be offered:** Online.

**MECH 408 – Applied Engineering Economy: Application to Energy & the Environment**
- **Delivery Method:** On-campus & online section available
- **Potential Term Offered:** Spring
- **Prerequisite:** MATH 161
- **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**
- **Delivery Method:** On-campus
- **Potential Term Offered:** Spring
- **Prerequisite:** CIVE 360 & MECH 331A&B
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 affect manufacturability. The course balances the fundamental aspects of materials processing with descriptive content regarding traditional forms of manufacturing.

MECH 417 – Control Systems
Delivery Method: On-campus
Potential Term Offered: Fall
Prerequisite: MATH 340 & MECH 307
Description: Feedback and forward loop control design and simulation; discrete time and frequency domain methods with implementation considerations. Sections may be offered: Online.
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 420 – Aerospace Structures
Delivery Method: On-campus
Potential Term Offered: Spring
Prerequisite: MECH 325 & MATH 340
Description: Analysis of aerospace structures; introduction to theory of elasticity, stress analysis of thin-walled structures in bending, torsion, and shear, and finite element methods and applications to aerospace structures. Sections may be offered: Online.

MECH 421 – Fundamentals of Wind Energy
Delivery Method: On-campus
Potential Term Offered: Spring
Prerequisite: CIVE 260 or MECH 262 & MATH 261
Description: This course aims to provide students with a fundamental knowledge of wind turbine operation, analysis, and design. The course covers the topics wind characteristics and resource prospecting, types and components of wind turbines, wind turbine materials, wind power conversion, calculation of annual energy production, aerodynamics of modern horizontal axis wind turbines, loads on horizontal axis wind turbines, electrical aspects and grid integration, wind turbine control system, siting, environmental impacts, an introduction to the economics of wind power generation, and rotor design fundamentals, codes, standards, and certifications. Sections may be offered: Online.

MECH 424 – Advanced Dynamics
Delivery Method: On-campus
Potential Term Offered: Spring
Prerequisite: MECH 324
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/).
Sections may be offered: Online.
MECH 425 – Mechanical Engineering Vibrations 4 credits

*Delivery Method:* On-campus  
*Potential Term Offered:* Fall  
*Prerequisite:* MECH 324  
*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 rotordynamics concepts.  
*Must register for lecture and laboratory.*

MECH 426 – Advanced Machine Design 3 credits

*Delivery Method:* On-campus  
*Potential Term Offered:* Fall  
*Prerequisite:* MECH 325 & MECH 331A&B  
*Description:* Advanced design of mechanical components to avoid / control failure during operation. Design and implementation of specific machine components for real-world applications, including correlations with advanced materials and advanced computational tools.  
*Sections may be offered: Online.*

MECH 428 – Probabilistic Design 3 credits

*Delivery Method:* On-campus  
*Potential Term Offered:* Fall  
*Prerequisite:* MATH 261 & MECH 231 or STAT 315 & MECH 325  
*Description:* Principles of probability, modeling of uncertainty, probability distributions, determination of distributions from observed data, probabilistic versus deterministic analysis, fundamental reliability analysis, first-order reliability analysis, sensitivity analysis, Monte-Carlo simulation, reliability-based design, topology optimization and generative design, design for manufacturing, prognostics fundamentals.  
*Sections may be offered: Online.*

MECH 431 – Metals and Alloys 3 credits

*Delivery Method:* On-campus  
*Potential Term Offered:* Fall  
*Prerequisite:* MECH 331A&B  
*Description:* Engineering metals and alloys, modification of properties by alloying, plastic deformation, and heat treatment. Fundamentals of physical metallurgy.

MECH 432 – Engineering of Nanomaterials 3 credits

*Potential Term Offered:* Fall (even years)  
*Prerequisite:* MECH 331A&B  
*Description:* Structure, properties, and processing of extremely small (10 to the minus 9 m) synthetic and natural materials.

MECH 434 – Materials Selection for Mechanical Design 3 credits

*Delivery Method:* On-campus  
*Potential Term Offered:* Fall  
*Prerequisite:* MECH 325 & MECH 331A&B  
*Description:* Understanding materials, their properties and behavior is fundamental to engineering design. The number of materials available to the engineer is vast: approximately 200,000 are available. Using a combination of lectures, case
histories, open-ended assignments and computer-based materials selectors, this course will cover procedures for selection the optimum materials(s) under multiple constraints resulting from functional, reliability, safety, cost and environmental issues. A variety of problems that illustrate materials-limited design and relationship between design and materials selection and processing will be covered.

*Sections may be offered: Online.*

**MECH 436 – Green Engineering – Materials and Environment**

*3 credits*

*Delivery Method: On-campus*

*Potential Term Offered: Fall, Spring*

*Prerequisite: MECH 325 & MECH331A*

*Description: Principles of green engineering in the context of materials, human dependence on materials, and the environmental consequences of materials selection. Perspective, background, methods, and data for evaluating and designing with materials to minimize the environmental impact.*

*Sections may be offered: Online.*

**MECH 437 – Internal Combustion Engines**

*3 credits*

*Delivery Method: On-campus*

*Potential Term Offered: Fall*

*Prerequisite: MECH 344*

*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 450 – Aerospace Propulsion**

*3 credits*

*Delivery Method: On-campus*

*Potential Term Offered: Fall*

*Prerequisite: MECH 342*

*Description: Material will first cover principles of thermodynamics and fluid dynamics required to characterize propulsion systems including foundational concepts of thrust, compressible flow, and boundary layer theory. The course will then cover characteristics of operation and analysis of common propulsion systems, including air breathing propulsion devices (turboprop, turbofan, turbojet, and hypersonic systems) and their respective components and will conclude with the analysis of chemical (solid, hybrid, and liquid) rocket systems.*

*Sections may be offered: Online.*

**MECH 460 – Aeronautics**

*3 credits*

*Delivery Method: On-campus*

*Potential Term Offered: Fall*

*Prerequisite: MECH 342*

*Description: This course is designed to provide engineering professionals and students with the fundamental concepts in aircraft performance and operability. Thermodynamics and fluid mechanics principles are applied towards the steady state analysis of performance parameters like aircraft endurance and range, ceiling, climb, descent, and glide. Aircraft transient operability notions like maneuverability, stability and control are covered using the classical control theory. Additionally, the course curriculum also introduces the basic concepts of*
aerial propulsion, allowing the course participants capture the fundamental understanding of all aspects of aircraft flight and appreciate the mechanics of the safest mode of transportation. Upon successful completion of this course, the participants should be able to:

1. calculate aircraft aerodynamics including lift and drag,
2. analyze aircraft performance including maximum velocity, range and endurance, take-off and landing,
3. evaluate airplane stability and control, and
4. conduct airplane propulsion calculations

MECH 463 – Building Energy Systems 3 credits
*Delivery Method: On-campus*
*Potential Term Offered: Spring*
*Prerequisite: MECH 344*
*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 464 – Injection Molding 3 credits
*Delivery Method: On-campus*
*Potential Term Offered: Fall*
*Prerequisite: MECH 200 or MECH 200A & MECH 301A & MECH 331A&B*
*Description: Injection molded parts are ubiquitous and the industry that designs and produces these parts is everywhere. This course is for engineering students interested in (a) designing parts for injection molding (b) working in the injection molding industry, and/or (c) knowing enough to determine when injection molded parts should be used in a particular product design. We will focus on thermoplastic injection molding. Students will design plastic parts, select appropriate materials and fillers, design the mold for manufacturing these parts, determine the process and cycle time for making these parts, identify necessary post-processing operations, and estimate part product cost and mold cost for making these parts. We will also discuss the molding of materials other than plastics as well as touching on other plastics processing such as vacuum forming, blow molding, and rotational molding.*

MECH 468 – Space Propulsion and Power Engineering 3 credits
*Delivery Method: On-campus*
*Potential Term Offered: Fall*
*Prerequisite: ECE 204 & MECH 337 & MECH 342*
*Description: Orbital mechanics and space missions; chemical, nuclear, and electric rockets; nuclear heat sources; thermoelectric and photovoltaic devices. The purpose of this course is to provide students with an understanding of the essential technologies required for introductory space mission analysis, specifically, spacecraft propulsion, power generation, and basic orbital mechanics used in simple space mission analysis.*
*Course Learning Objectives:*
1. Key rocketry concepts and performance parameters
2. Basic orbital mechanics and common orbital maneuvers
3. Nuclear physics related to reactor operation and design
4. Introductory solid state physics related to photovoltaic and thermoelectric generators

MECH 470 – Biomedical Engineering 3 credits
*Delivery Method: On-campus*
*Potential Term Offered: Fall*
**Prerequisite:** MATH 155 or MATH 160 & PH 141

**Description:** Engineering application in human/animal physiology, diagnosis of disease, treatment, rehabilitation, human genome manipulation.

**MECH 476 – Mechanical Engineering Data Analysis in R**

**3 credits**

**Delivery Method:** On-campus

**Potential Term Offered:** Fall

**Prerequisite:** MECH 201

**Description:** Data science is a growing field and a critical job skill for engineers in the 21st century. This course is designed to introduce students to data science and to provide them with data analysis skills using the R programming language - an open-source tool for data science in STEM. Topics covered include cleaning and manipulation of “big data”, exploratory data analysis and visualization, and applications related to sampling and measurement, calibration, figures of merit, and modeling. Sections may be offered: Online.

Upon successful completion of the course, students will be able to:

1. import, organize, and manipulate data files using R/RStudio,
2. share code, post issues, and manage datasets on GitHub,
3. conduct exploratory data analysis on engineering datasets,
4. create data visualizations using the R programming language,
5. diagnose and interpret descriptive features of datasets such as central tendency, quantiles, spread, and shift.
6. apply engineering data analysis techniques (e.g., calibration, linear modeling, figures of merit) to mechanical engineering datasets.

**MECH 477 – Algorithms in Scientific Computing**

**3 credits**

**Delivery Method:** On-campus

**Potential Term Offered:** Spring (even years)

**Prerequisite:** MATH 340 or MATH 345.

**Description:** Numerical methods for scientific computing relevant to problems arising in mechanical and aerospace engineering, with an emphasis on applications, mathematical principles and algorithms, code development, and tool building.

**MECH 478 – Computational Fluid Dynamics**

**3 credits**

**Delivery Method:** On-campus

**Potential Term Offered:** Fall

**Prerequisite:** MECH 342

**Description:** Introduction to fundamentals of numerical analysis, ordinary differential equations and partial differential equations related to fluid mechanics. Study of error control, stability considerations, and convergence issues. Application of modern CFD software including geometry building, mesh generation, solution methods, and flow analysis and visualization.

Sections may be offered: Online.

**MECH480A5 - Vehicle Dynamics**

**3 credits**

**Delivery Method:** On-campus

**Potential Term Offered:** Spring

**Prerequisite:** MECH 324

**Description:** This course will cover steady-state and transient response and control of vehicle suspension systems. That is: ride and handling. The first, ride, is a measure of driver and passenger comfort as a function of a variety of vehicle response variables in pitch, heave, roll and yaw. The second, handling, is associated with creating maximum lateral and longitudinal response of the vehicle. We shall see that ride and handling tend to be inversely proportional. That is, maximizing ride negatively affects handling, and maximizing handling negatively affects ride. Clearly, the suspension of the production, street legal 2018 Lamborghini Aventador LP770-4 SVJ (the current fastest production, street legal car to lap the Nürburgring Nordschleife – 6:44.97) must differ from the
2018 Lexus LS 500 – having an amazingly smooth, quiet and luxurious ride. The question here is not: Which is best? It is: How does one design and analyze the best suspension system given the holistic vehicle design goals?

Automotive engineers use the acronym NVH - Noise, Vibration and Handling – to discuss these topics. In this course, NVH is examined from 3 perspectives:
1. Component level – tires, dampers and struts, springs (leaf, torsion, coil), braking systems, steering components and Ackermann steering, and general suspension styles (independent, solid axle, de Dion, McPherson strut, …) We will study each as a separate system without regard to contribution to a holistic suspension response system.
2. Kinematic and kinetic analysis – roll centers, roll axes, instant centers, the all-important roll gradient, steer angles, anti-dive, anti-squat … These will merge in longitudinal and lateral steady-state response equations for vehicles.
3. Vibrations, in an introduction to first-order free and forced transient response in all nine vehicle vibration modes (chassis heave, pitch, roll and yaw, and four wheel bounce modes).

**MECH480A6 – Compressible Flow**

*Delivery Method: On-campus*

*Potential Term Offered:* Fall, Spring

*Prerequisite:* MECH 342

*Description:* This course provides a comprehensive introduction to the effects of acoustic transport in fluids, a result of compressibility. Topics include inviscid conservation laws, acoustic propagation, normal shock waves, oblique shock and expansion waves, quasi-one-dimensional flow, unsteady waves, and conical flow.

*Course Learning Objectives:*
1. design a supersonic inlet
2. design and contour a rocket nozzle
3. analyze supersonic flow around wings and bodies
4. optimize the aspiration of an internal combustion engine
5. design a hypersonic waverider vehicle

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

**MECH 502 – Advanced/Additive Manufacturing Engineering**

*Delivery Method: On-campus*

*Potential Term Offered:* Fall (Online Only), Spring

*Prerequisite:* MECH 202 & MECH 331A&B

*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. *(To view online credit courses, please see the following link: [https://www.online.colostate.edu/courses/credit](https://www.online.colostate.edu/courses/credit)).* *Sections may be offered: Online.*

**MECH 505 – Stream Power Plants**

*Delivery Method: On-Campus*

*Potential Term Offered:* Spring

*Prerequisite:* MECH 344

*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.

Sections may be offered: Online.

**MECH 507 – Laser Diagnostics for Thermosciences** 3 credits
*Delivery Method: On-campus*
*Potential Term Offered: Spring (odd years)*
*Prerequisite: PH 142*
*Description: Basics of optics, spectroscopy, and lasers. Physics and applications of laser diagnostic techniques used in Thermosciences.*
*Sections may be offered: Online.*

**MECH 509 – Design and Analysis in Engineering Research** 3 credits
*Delivery Method: On-campus*
*Potential Term Offered: Spring*
*Prerequisite: MATH 340 & STAT 315*
*Description: Design, model building, analysis and reporting in engineering and manufacturing research and experimentation.*
*Sections may be offered: Online.*

**MECH 513 – Simulation Modeling and Experimentation** 3 credits
*Delivery Method: On-campus*
*Potential Term Offered: Spring*
*Prerequisite: STAT 315*
*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: MECH 324*
*Description: Structural modal analysis, rotor dynamics, and torsional vibrations. Lectures are supported with practical application labs. (Must register for lecture and laboratory).*

**MECH 516 – Life Cycle and Techno-Economic Assessment** 3 credits
*Delivery Method: On-campus*
*Potential Term Offered: Spring*
*Prerequisite: MECH 331A&B & MECH 344*
*Description: The course covers sustainability through economic and environmental impact assessment. Students will be exposed to methods for evaluating technologies based on sustainability performance. Skills perforating
systems level assessment will be developed and demonstrated. Life cycle assessment includes greenhouse gas accounting (carbon footprint), water footprint methods, and other environmental impact areas. Techno-economic assessment includes estimating capital costs and operational costs and performing discounted cash flow rate of return analysis to determine minimum selling prices. The course includes case studies in the area of energy with students doing a project on a topic of their choice.

Sections may be offered: Online.

MECH 517 – Chemical Rocket Propulsion
Delivery Method: On-campus
Potential Term Offered: Spring
Prerequisite: MECH 342
Course Description: Principles of chemical rocket propulsion theory, including practical applications of rocket propulsion system design and analysis.

MECH 520 – Finite Element Analysis in Mechanical Engineering
Potential Term Offered: Spring
Prerequisite: CIVE 360 & MATH 340 or MATH 530
Description: Application of FEA as a tool to analyze mechanical engineering problems.

MECH 524 – Principles of Dynamics
Delivery Method: On-campus
Potential Term Offered: Fall
Prerequisite: MECH 324
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. Sections may be offered: Online.

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
Delivery Method: Online
Potential Term Offered: Fall
Prerequisite: BC 351 or BMS 300 or BMS 500 or BZ 310 or NB 501
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 527 – Hybrid Electric Vehicle Powertrains
Delivery Method: On-campus
Potential Term Offered: Fall
Prerequisite: MECH 307
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

Delivery Method: On-campus
Potential Term Offered: Fall
Prerequisite: MECH 307

Description: Modeling, analysis, and synthesis of practical mechanical devices in which dynamic response is dominant consideration. Sections may be offered: Online.

Course Learning Objectives:
Upon the completion of this course, you should be able to:
1. Apply the techniques of modal analysis, multidomain system dynamics, and modern controls using computational tools.
2. Apply these tools to problems of large scale, real-world complicatedness, and practical interest.
3. Perform computational system design and optimization.

MECH 530 – Advances Composite Materials

Delivery Method: On-campus & online section available
Potential Term Offered: Fall
Prerequisites: CIVE 360 & MECH 331A&B

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

Delivery Method: On-campus & online section available
Potential Term Offered: Spring
Prerequisites: MECH 331A&B & MECH 431

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

Delivery Method: On-campus & online section available
Potential Term Offered: Fall
Prerequisite: MECH 331A&B

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

Delivery Method: On-campus
Potential Term Offered: Fall
Prerequisites: MECH 331A&B & CIVE 360
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 534 – Energy and Environmental Impacts of Transportation
Delivery Method: On-campus
Potential Term Offered: Spring
Prerequisite: MECH 337
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.

MECH 535 – Mechanics of Composite Materials
Delivery Method: On-campus
Potential Term Offered: Spring (even years)
Prerequisite: MATH 340 & MECH 325 & MECH 331A&B
Description: Classical lamination theory of fiber-reinforced composite materials; Mechanical behavior of composite laminates and honeycomb structures; Failure modes and failure criteria. Design of composite structures; Computer modeling of composites.
Sections may be offered: Online.

MECH 537 – Processing of Polymer Composites
Delivery Method: On-campus
Potential Term Offered: Spring (odd years)
Prerequisite: CIVE 360 & MECH 331A&B
Description: Basic principles of the processing science of polymer composites, physical and chemical phenomena that occur during manufacturing processes, and solutions to address issues that arise.
Sections may be offered: Online.

MECH 538 – Mechanical Engineering Thermodynamics
Delivery Method: On-campus
Potential Term Offered: Fall
Prerequisite: MECH 337
Description: The course covers applications of thermodynamic principles in power generation, propulsion, and air conditioning systems through power cycles and combustion concepts. Sections may be offered: Online.
Course Learning Objectives:
1. To apply mass, energy, and entropy balances to closed and open systems.
2. To perform thermodynamic analysis of vapor and gas power cycles.
3. To perform thermodynamic analysis of refrigeration and heat pump cycles.
4. To express the properties of multicomponent mixtures and use psychometrics.
5. To model combustion processes and related them to energy systems.

MECH 539 – Advanced Fluid Mechanics
Potential Term Offered: Fall
Prerequisite: CIVE 300 or MECH 342

Description: Kinematics, Navier-Stokes equations, vorticity, viscous flows, scaling analysis, boundary layers, secondary flows, entropy generation and transport, stability and transition, turbulence.

MECH 543 – Biofluid Mechanics  

Delivery Method: On-campus & online section available  

Potential Term Offered: Spring (odd years)  

Prerequisites: MECH 342 or CIVE 300 or BMS 300 & PH 121 or BMS 300 & PH 141 or BMS 420  

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  

Delivery Method: On-campus  

Potential Term Offered: Spring  

Prerequisite: MECH 344  

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 with 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  

Delivery Method: On-campus  

Potential Term Offered: Fall (odd years)  

Prerequisite: MECH 342  

Description: Characteristics of real gases in reacting and nonequilibrium systems; equilibrium air; statistical mechanics, chemical thermodynamics.

MECH 552 – Applied Computational Fluid Dynamics  

Delivery Method: On-campus  

Potential Term Offered: Fall (odd years)  

Prerequisite: CIVE 300 or CBE 331 or MECH 342  

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 553 – Industrial Engines 3 credits
Delivery Method: On-campus
Potential Term Offered: Spring
Prerequisite: MECH 237 or MECH 337
Description: Technology review, and application of engineering sciences and economics to the analysis and design of large industrial engines. Combustion cycles, fuels, emissions control, and auxiliary systems associated with industrial engines are examined. Study overall systems design of engines as well as application requirements and design limitations.

MECH 557 – Turbomachinery 3 credits
Delivery Method: On-campus
Potential Term Offered: Spring
Prerequisite: MECH 337 & MECH 342
Description: This course covers the application of fundamental principles of thermodynamics and fluid mechanics to turbomachinery. Turbomachines, also known as fluid machinery, are devices in which energy is transferred between a spinning rotor and a fluid moving through it. Compressors, pumps, fans, blowers, and turbines are all examples of turbomachines. The topics covered in the course include types of turbomachines, selection of appropriate fluid machinery for a specific application, derivation of energy transfer equations, and engineering analysis of design and performance characteristics of turbomachines. Sections may be offered: Online.

Upon successful completion of this course, students will be able to:
1. Apply fundamental principles of thermodynamics and fluid mechanics to fluid machinery.
2. Apply dimensional analysis in turbomachinery design and evaluation.
3. Evaluate various turbomachinery types to appropriately select for a given application.
5. Apply knowledge of fluid flow to design turbomachinery cascade configurations.
6. Create turbomachinery component design using engineering design tools.

MECH 558 – Combustion 3 credits
Delivery Method: On-campus
Potential Term Offered: Fall (even years)
Prerequisite: MECH 342
Description: Combustion refers to the study of chemically reacting fluid systems. Thus, this course utilizes all of the fundamental tools acquired during the study of Chemistry, Thermodynamics, Heat Transfer, and Fluid Mechanics. Sections may be offered: Online.

Upon completion of this course, each student will be able to:
1. Calculate adiabatic flame temperatures using the concepts of chemical equilibrium.
2. Derive the Arrhenius rate expression from simple kinetic theory.
3. Explain qualitatively the chemical oxidation mechanism of a wide range of fuels using elementary chemical kinetic arguments.
4. Assemble detailed chemical kinetic mechanisms and model zero and one-dimensional chemically reacting systems using reaction design software.
5. Calculate premixed laminar flame speed using phenomenological arguments and perform complex laminar flame calculations using reaction design software.
6. Derive governing equations to study premixed and non-premixed reacting flows/flames
7. Explain the formation mechanisms of NOx, HC, CO and PM in combustion systems and how to design systems with low pollutant formation.

MECH 564 – Fundamentals of Robot Mechanics and Controls 3 credits
Delivery Method: On-campus
Potential Term Offered: Spring
Prerequisite: MECH 417


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
3 credits

Potential Term Offered: Spring (odd years)
Prerequisite: MATH 340

Description: Physical processes in broad-beam electron-bombardment ion sources for space propulsion and ion machining applications.

MECH 568 – Computational Methods for Mechanical Engineering
3 credits

Delivery Method: On-campus
Potential Term Offered: Fall
Prerequisites: MATH 450 or MATH 451

Description: In ME, many research areas have an associated computational aspect. Computational fluid dynamics simulations (gas dynamics, fluid mechanics, bio-fluids, etc.), finite element simulations, and particle interaction simulations are applied regularly to study fluid-thermal, fluid-structure, and mechanical systems at all scales. In addition, new computational methods and techniques are being developed to advance the state-of-the-art in simulation capacity. The goal of the software user is to generate a solution that is useful, trustworthy, and accurate; the goal of the software developer is to make this as likely as possible. A great deal of knowledge and expertise of the fundamentals in computational methods and mathematics is needed not only to develop algorithms and models, but also to apply them successfully. This course is designed as a computational and mathematical core course for ME graduate students who seek a deep understanding of the mathematical and computational fundamental principles which provide the foundation for the software and algorithms used in ME. The purpose of this course is to provide the foundation needed to achieve the above goals of both users and developers.

MECH 569 – Micro-Electro-Mechanical Devices
3 credits

Delivery Method: On-campus
Potential Term Offered: Spring
Prerequisite: MECH 344 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.
Sections may be offered: Online.

MECH 570 – Bioengineering
3 credits

Delivery Method: On-campus & online section available
Potential Term Offered: Spring
Prerequisites: MECH 307 & MECH 324
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  
Delivery Method: Online  
Potential Term Offered: Spring  
Prerequisite: MECH 331A&B  
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.  
Sections may be offered: Online.

MECH 574 – Bio-Inspired Surfaces  
Delivery Method: On-campus & online section available  
Potential Term Offered: Spring  
Prerequisites: MECH 342 & CHEM 111  
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 plant 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.  
Sections may be offered: Online.

MECH 575 – Solar and Alternative Energies  
Delivery Method: On-campus  
Potential Term Offered: Spring  
Prerequisites: MECH 337 & MECH 342 & MECH 344  
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  
Delivery Method: On-campus & online section available  
Potential Term Offered: Spring  
Prerequisites: BMS 300 & CHEM 113 & MATH 340 & PH 142  
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  
Delivery Method: On-campus  
Potential Term Offered: Spring (odd years)
Prerequisite: PH 141

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

Delivery Method: On-campus
Potential Term Offered: Fall
Prerequisite: CIVE 360

Description: Application of engineering concepts to quantify the mechanical behavior of load-bearing biological tissues and orthopaedic implant performance.

Sections may be offered: Online.

MECH 579 – Cardiovascular Biomechanics

Delivery Method: On-campus
Potential Term Offered: Fall
Prerequisite: MATH 340 & PH 142

Description: Bio-mechanical principles and approaches applied in cardiovascular research.

Graduate students only. *Credit allowed for only one of the following: BIOM 579, BIOM 581A8, MECH 579, or MECH 581A8. Sections may be offered: Online.

Course Learning Objectives:
Upon completing this course, students will be able to (1) describe and apply basic principles of biomechanics in the cardiovascular system, (2) comprehend and apply quantitative approaches (in vivo and in vitro) to measure biomechanical properties of cardiovascular tissues (including blood vessels and cardiac tissues), (3) comprehend, explain, and interpret structure-function relationship in cardiovascular tissues, (4) describe the vessel-vessel and ventricular-vascular biomechanical interactions, (5) summarize the exploitation of biomechanics in cardiovascular therapy, (6) identify cardiovascular medical problems and be able to apply biomechanical principles/tools to solve them.

MECH 580A9 – Regenerative Bioengineering with Stem Cells

Delivery Method: On-campus
Potential Term Offered: Spring
Prerequisites: BC 351 or BMS 300 or BZ 310.

Description: Current status and future direction of bioengineering and regenerative technologies with stem cells, including sorting, creation and preservation technologies with stem cells, large scale stem cell manufacturing and bioengineering strategies, mechanobiology of stem cells, genetic and epigenetic engineering of stem cells, engineering stem cells for translational and clinical success. (Sections may be offered: Online).

MECH 580B3 – Orbital Mechanics

Delivery Method: On-campus
Potential Term Offered: Spring
Prerequisites: MATH 340 & PH 142

Description: This course will provide the knowledge and skills to design orbital missions. The class will cover orbital elements, motion, and analyses, and the design and characteristics of the common orbit regimes. It will provide a detailed focus on orbital maneuver options and design, and progress through interplanetary missions. An emphasis will be made on developing technical analytical capabilities, engineering judgement, and intuitive
understanding of orbital maneuvers and each of the main orbit regimes. The course will also cover mission design, orbit perturbations, and relative motion/rendezvous. Integration of provided MATLAB scripts and Systems Tool Kit software throughout the course will allow efficient analytical and visual investigation while providing extensive insight into the principles and mechanics of orbits.

**MECH 580B4 – Trajectory and Performance**

*3 credits*

*Delivery Method:* On-campus

*Potential Term Offered:* Spring

*Prerequisites:* MATH 340 & PH 142

*Description:* This class is designed to provide the skills necessary to contribute to the rapidly expanding launch vehicle industry. This class will overview of orbital mechanics theory, elements, and orbit regimes, investigate trajectory modeling physics and philosophy, and then implement the theories to design and optimize trajectories to six orbits over the course of the semester (LEO, GTO, Sun Synch, Molniya, GEO, and Interplanetary). Launch vehicle conceptual design and sizing will be used to create the vehicles modeled and investigation of optimal staging, ideal velocity and its use in margins and prediction of mission losses. A focus will be made, for each of the orbit regime trajectories, on technical analysis capabilities, controls and constraints modeling, parametric assessments, engineering judgement, and intuitive understanding. The course will discuss ascent design and the required systems mindset to integrate aero, thermal, loads, acceleration, and the numerous other constraints. Use of the NASA GSFC Generalized Mission Analysis Tool will be incorporated as a user-friendly trajectory simulation tool that allows building and optimizing sophisticated trajectories. Integration of MATLAB-Simulink modeling and Systems Tool Kit software into the course will allow efficient analytical and visual investigation while providing extensive insight into the trajectory design process.

*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 350A – 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.

*This course can count as an ME TE or an ALT TE.*

**BMS 300 – Principles of Human Physiology**

*Potential Term Offered: Fall, Spring, Summer*

*Prerequisite:* BZ 101 or BZ 110 or LIFE 102 & CHEM 103 or CHEM 107 or CHEM 111

*Description:* Physiology of humans.

**CIVE 367 – Structural Analysis**

*Potential Term Offered: Fall, Spring*

*Prerequisite:* CIVE 360

*Description:* Determination of actions in and deformations of determinate and indeterminate structures.

**CIVE 438 – Environmental Engineering Concepts**

*Potential Term Offered: Fall, Spring*

*Prerequisite:* CHEM 113 & CIVE 300 or CBE 331 or MECH 342

*Description:* Environmental engineering approaches to designing water supply, wastewater removal, and pollution control systems.

**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 150A – Culture and Coding: Java (GT-AH3)**

*3 credits*
**Potential Term Offered:** Fall, Spring  
**Prerequisite:** None  
**Description:** Survey of computer science, formal logic, and computational thinking. Explores the historical, gender, and cultural perspectives on the role of technology in society. Includes learning basic elements of the Java programming language. Write small programs, and construct written arguments on ways in which technology influences our modern culture. Previous computer science experience not necessary. *Must register for lecture and laboratory. Sections may be offered: Online. Credit allowed for only one of the following: CS 150, CS 150A, or CS 150B.*  
*This course can satisfy AUCC3B and ALT Technical Elective credit. Connect with your academic advisor.*

**CS 150B – Culture and Coding: Python (GT-AH3) * 3 credits**  
**Potential Term Offered:** Fall, Spring  
**Prerequisite:** None  
**Description:** Survey of computer science, formal logic, and computational thinking. Explores the historical, gender, and cultural perspectives on the role of technology in society. Includes learning basic elements of the Python programming language. Write small programs, and construct written arguments on ways in which technology influences our modern culture. Previous computer science experience not necessary. *Must register for lecture and laboratory. Sections may be offered: Online. Credit allowed for only one of the following: CS 150, CS 150A, or CS 150B.*  
*This course can satisfy AUCC3B and ALT Technical Elective credit. Connect with your academic advisor.*

**CS 155 – Introduction to Unix 1 credit**  
**Potential Term Offered:** Fall, Spring, Summer  
**Prerequisite:** None  
**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:** CS 155 (may be taken concurrently) & MATH 118  
**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:** CS 156 (may be taken concurrently) & MATH 118  
**Description:** More basic design types, function usage and strings. Arrays, user-defined types and structures, enumerated types, recursion, dynamic storage allocation

**CS 164 – Java (CS1) Prior Programming 4 credits**  
**Potential Term Offered:** Fall, Spring  
**Prerequisite:** CIS 240 with a minimum grade of C or CS 150A with a minimum grade of C or CS 150B with a minimum grade of C  
**Prerequisite:** CS 152 with a minimum grade of C or MATH 124 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.

**ECE 411 – Control Systems 4 credits**  
**Potential Term Offered:** Fall  
**Prerequisite:** ECE 312 with a minimum grade of C  
**Description:** 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:** ECE 202 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**  
**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**  
**Potential Term Offered:** Fall, Spring, Summer  
**Prerequisite:** MATH 125 (may be taken concurrently)  
**Description:** Anatomical, physiological, and mechanical fundamentals of human movement.

**IDEA 310E – Design Thinking Toolbox: Wood**  
**Potential Term Offered:** Spring  
**Prerequisite:** IDEA 210 (may be taken concurrently)  
**Description:** Within a design thinking approach, the designer or maker is concerned primarily with the interaction of people with the thing, system, or idea they are building. The goal of this class is threefold, to teach the fundamentals of designing and building which are specific to wood, to form a thorough understanding of safe usage of wood working equipment, and to create a series of projects that employ the iterative design principals which are at the core of design thinking.

**MATH 331 – Introduction to Mathematical Modeling**  
**Potential Term Offered:** Fall  
**Prerequisite:** MATH 161 (may be taken concurrently) & MATH 229 (may be taken concurrently) or MATH 369 (may be taken concurrently)  
**Description:** Problem formulation. Modeling, theoretical and empirical. Variable selection. Derivation and simulation of solutions. Model testing including prediction.

**MATH 332 – Partial Differential Equations**  
**Potential Term Offered:** Spring  
**Prerequisite:** MATH 340 or MATH 345  
**Description:** Partial differential equations, separation of variables, Fourier series and transforms, Laplace, heat and wave equations.

**MATH 369 – Linear Algebra I**  
**Potential Term Offered:** Fall, Spring, Summer  
**Prerequisite:** MATH 161 or MATH 255 or MATH 271  
**Description:** Linear systems, matrices, subspaces of Euclidean spaces, linear transformations on Euclidean spaces, eigenvalues, and eigenvectors.

**MGT 305 – Fundamentals of Management**  
**Potential Term Offered:** Fall, Spring, Summer  
**Prerequisite:** None
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: None*
*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: AREC 202 or ECON 101 or ECON 202*
*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** 4 credits
*Potential Term Offered: Spring*
*Prerequisites: MATH 261 (may be taken concurrently) & PH 142*
*Description: Relativity; quantum mechanics; atomic structure; applications to solid-state, nuclear, and elementary particle physics.*

**PH 341 – Mechanics** 4 credits
*Potential Term Offered: Fall*
*Prerequisites: MATH 340 or MATH 345 & PH 142*
*Description: Particle dynamics, translation and rotation of rigid bodies, moving coordinate systems, Lagrangian mechanics, matrix and tensor methods.*

**PH 353 – Optics and Waves** 4 credits
*Potential Term Offered: Fall*
*Prerequisites: MATH 261 & PH 142*
*Description: Geometrical optics; wave optics; interference, diffraction, and polarization; quantum optics.*

**PH 451 – Introductory Quantum Mechanics I** 3 credits
*Potential Term Offered: Fall*
*Prerequisite: MATH 340 or MATH 345 & PH 314*
*Description: Schrodinger's theory of wave mechanics, potential wells, harmonic oscillators, wave packets, operators, angular momentum.*

**STAT 315 – Statistics- Theory and Practice** 3 credits
*Potential Term Offered: Fall, Spring, Summer*
*Prerequisite: MATH 155 or MATH 159 or MATH 160*
*Description: Descriptive statistics, probability theory, random variables, sampling distributions, hypothesis testing, confidence intervals, ANOVA, simple and multiple regression. R software is utilized for analyzing real world data sets.*

**Restricted Alternate (Minimum cumulative GPA of 3.0 is required):**

**ENGR/ECE 501 – Foundations of Systems Engineering** 3 credits
*Potential Term Offered: Fall, Spring*
*Prerequisite: None*
*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** 3 credits
Potential Term Offered: Fall  
Prerequisite: CIVE 300  
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: CIVE 360  
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: CIVE 261 & CIVE 360  
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.  
**This course will not fulfill a MECH Technical Elective or an Alternate Technical Elective requirement.**