Senior Specialization – Technical Elective 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 Engineering	Automotive Engineering	Biomedical Engineering	Energy Engineering	Material Science & Manufacturing	Robotics and Controls	Simulation and Modeling	Dynamic Systems	Systems Engineering	Thermal and Physical Sciences
MECH 403	Energy Engineering				x						
MECH 407	Laser Applications in Mechanical Engineering	x				x					x
MECH 408	Applied Engineering Economy									x	
MECH 411	Manufacturing Engineering					x					
MECH 417	Control Systems	x					x				
MECH 420	Aerospace Structures	x									
MECH 421	Fundamentals of Wind Energy				x						
MECH 424	Advanced Dynamics	x							x		
MECH 425	Mechanical Engineering Vibrations								x		
MECH 426	Advanced Machine Design	x									
MECH 428	Probabilistic Design					x					
MECH 431	Metals and Alloys					x					
MECH 432	Engineering of Nanomaterials					x					
MECH 434	Materials Selection for Mechanical Design	x	x			x					
MECH 437	Internal Combustion Engines		x								x
MECH 450	Aerospace Propulsion	x									
MECH 460	Aeronautics	x									
MECH 463	Building Energy Systems				x						
MECH 464	Injection Molding							x			
MECH 468	Space Propulsion and Power Engineering	x			x						
MECH 470	Biomedical Engineering			x							
MECH 476	Mechanical Engineering Data Analysis in R								x		
MECH 477	Algorithms in Scientific Computing					x					
MECH 478	Computational Fluid Dynamics							x			
MECH 502	Advanced/Additive Manufacturing Engineering	x				x					
MECH 505	Stream Power Plants				x						
MECH 507	Laser Diagnostics for Thermosciences										x
MECH 509	Design and Analysis in Engineering Research							x			
MECH 513	Simulation Modeling and Experimentation							x			
MECH 515	Advanced Topics in Mechanical Vibrations	x							x		
MECH 516	Life Cycle and Techno-Economic Assessment									x	
MECH 517	Chemical Rocket Propulsion	x									
MECH 520	Finite Element Analysis in Mechanical Engineering	x						x			
MECH 524	Principles of Dynamics								x		
MECH 525	Cell and Tissue Engineering			x							
MECH 527	Hybrid Electric Vehicle Powertrains		x								
MECH 529	Advanced Mechanical Systems						x	x	x		
MECH 530	Advances Composite Materials	x				x					
MECH 531	Materials Engineering	x				x					
MECH 532	Materials Issues in Mechanical Design	x				x					
MECH 533	Composites Product Development					x					
MECH 534	Energy and Environmental Impacts of Transportation		x		x						
MECH 535	Mechanics of Composite Materials					x					
MECH 537	Processing of Polymer Composites	x				x					
MECH 538	Mechanical Engineering Thermodynamics										x
MECH 539	Advanced Fluid Mechanics	x									x
MECH 543	Biofluid Mechanics			x							x
MECH 544	Advanced Heat Transfer										x
MECH 551	Physical Gas Dynamics l	x									x
MECH 552	Applied Computational Fluid Dynamics							x			
MECH 553	Industrial Engines		x								
MECH 557	Turbomachinery	x			x						
MECH 558	Combustion	x	x		x						
MECH 564	Fundamentals of Robot Mechanics and Controls					x	x				
MECH 567	Broad-Beam Ion Sources	x									x
MECH 568	Computational Methods for Mechanical Engineering							x			
MECH 569	Micro-Electro-Mechanical Devices						x				
MECH 570	Bioengineering			x							
MECH 573	Structure and Function of Biomaterials			x		x					
MECH 574	Bio-Inspired Surfaces			x		x					
MECH 575	Solar and Alternative Energies				x						
MECH 576	Quantitative Systems Physiology			x							
MECH 577	Aerosol Physics and Technology										x
MECH 578	Musculoskeletal Biosolid Mechanics			x							
MECH 579	Cardiovascular Biomechanics			x							

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 **3 credits**
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 **3 credits**
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 **3 credits**
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 **3 credits**
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 effect manufacturability. The course balances the fundamental aspects of materials processing with descriptive content regarding traditional forms of manufacturing.

MECH 417 – Control Systems **3 credits**
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 **3 credits**
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 **3 credits**
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 **3 credits**
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

aircraft 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 **3 credits**
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 **3 credits**
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). Sections may be offered: Online.*

MECH 505 – Stream Power Plants **3 credits**
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.
5. Prepare for advanced courses in Thermodynamics, Thermal Systems, and Combustion.

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 **3 credits**
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 **3 credits**
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 **3 credits**
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 **3 credits**
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 **3 credits**
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 **3 credits**
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 **3 credits**
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 **3 credits**
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 **3 credits**
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 **3 credits**
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 **3 credits**
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 **3 credits**
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 **3 credits**
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 **3 credits**
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 **3 credits**
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 **3 credits**
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 **3 credits**
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 l **3 credits**
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 **3 credits**
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.
4. Analyze performance of turbomachinery.
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 **3 credits**
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 **3 credits**
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 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.
Sections may be offered: Online.

MECH 575 – Solar and Alternative Energies **3 credits**
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 **3 credits**
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 **3 credits**
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 **3 credits**
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 **3 credits**
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 **3 credits**
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 **3 credits**
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 **1-2 credits**

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 **4 credits**

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 **3 credits**

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 **3 credits**

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 **3 credits**

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 **or** 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 **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: MATH 125 *(may be taken concurrently)*
Description: Anatomical, physiological, and mechanical fundamentals of human movement.

IDEA 310E – Design Thinking Toolbox: Wood **2 credits**
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 **3 credits**
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 **3 credits**
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 l **3 credits**
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 **3 credits**
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 l **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 **3 credits**
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 **3 credits**
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 **1 credit**
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.**