# Senior Specialization – Technical Electives Categorization

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

| | | Aerospace 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 303 | Energy Engineering | | | | x | | | | | | |
| MECH 4XX | Aerospace Propulsion | x | | | | | | | | | |
| MECH 4XX | Advanced Mechanical Design | x | | | | | | | | | |
| MECH 4XX | Advanced Manufacturing Aspects of Industry 4.0 | | | | | x | | | | | |
| MECH 4XX | Production Manufacturing | | | | | x | | | | | |
| MECH 4XX | Probabilistic Design | | | | | 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 424 | Advanced Dynamics | x | | | | | | | x | | |
| MECH 425 | Mechanical Engineering Vibrations | | | | | | | | x | | |
| MECH 431 | Metals and Alloys | | | | | x | | | | | |
| MECH 432 | Engineering of Nanomaterials | | | | | x | | | | | |
| MECH 433 | Composites Product Development | x | | | | x | | | | | |
| MECH 437 | Internal Combustion Engines | | x | | | | | | | | x |
| MECH 452 | Applied Computational Fluid Dynamics | x | | | | | | | | | |
| MECH 460 | Aeronautics | x | | | | | | | | | |
| MECH 463 | Building Energy Systems | | | | x | | | | | | |
| MECH 468 | Space Propulsion and Power Engineering | x | | | x | | | | | | |
| MECH 470 | Biomedical Engineering | | | x | | | | | | | |
| MECH 480A6 | Compressible Flow | x | | | | | | | | | |
| MECH 481A3 | Materials Selection for Mechanical Design | x | x | | | x | | | | | |
| MECH 481A5 | Fundamentals of Wind Energy | | | | x | | | | | | |
| MECH 5XX | Mechanics of Composite Materials | x | | | | | | | | | |
| MECH 5XX | Welding | | | | | x | | | | | |
| MECH 502 | Advanced/Additive Manufacturing Engineering | x | | | | x | | | | | |
| MECH 505 | Stream Power Plants | | | | x | | | | | | |
| MECH 507 | Laser Diagnostics for Thermosciences | | | | | | | | | | x |
| MECH 511 | Engineering Decision Making under Uncertainty | | | | | | | | | x | |
| MECH 515 | Advanced Topics in Mechanical Vibrations | x | | | | | | | x | | |
| MECH 520 | Finite Element Analysis in Mechanical Engineering | x | | | | | | x | | | |
| MECH 523 | Vehicle Energy Storage System Design | | x | | x | | | | | | |
| MECH 524 | Principles of Dynamics | | | | | | | | x | | |
| MECH 525 | Cell and Tissue Engineering | | | x | | | | | | | |
| MECH 526 | Fundamentals of Vehicle Dynamics | | x | | | | | | 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 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 I | x | | | | | | | | | x |
| MECH 552 | Applied Computational Fluid Dynamics | | | | | | | 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 | | | | | | | |
| MECH 580A8 | Transportation, Energy, and the Environment | | | | x | | | | | | |
| MECH 580B1 | Industrial Gas and Dual-Fuel Engines | | x | | | | | | | | |
| MECH 580B2 | Mechanical Vibrations | x | x | | | | x | | x | | |
| MECH 581A4 | Chemical Rocket Propulsion | x | | | | | | | | | |
| MECH 581A7 | Thermal Energy Systems Design and Analysis | | | | | | | | | x | x |
| MECH 581A9 | Processing of Polymer Composites | x | | | | 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 303 – Energy Engineering** **3 credits**

*Delivery Method:* On-campus

*Potential Term Offered*: Fall

*Prerequisite*: MECH237 **or** MECH337 **or** CBE310 **or** ECE341 **or** PH361

*Description*: Covers a variety of renewable energy technologies. The class uses foundational heat and mass and fluids to evaluate and understand various renewable energy technologies. Course topics include, solar energy, solar PV, hydro, wind, biofuels, among other energy generation technologies. To provide students an appreciation for the need and promise of simultaneously renewable, alternative, and "clean" energy technologies.

**MECH 407 – Laser Applications in Mechanical Engineering** **3 credits**

*Delivery Method:* On-campus

*Potential Term Offered:* Fall

*Prerequisite:* PH142

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

**MECH 408 – Applied Engineering Economy: Application to Energy & the Environment** **3 credits**

*Delivery Method:* On-campus & online section available

*Potential Term Offered:* Spring

*Prerequisite:* MATH161

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

**MECH 411 – Manufacturing Engineering** **3 credits**

*Delivery Method:* On-campus & online section available

*Potential Term Offered:* Spring

*Prerequisite:* CIVE360 **&** MECH331

*Description:* Casting, forming, machining and welding processes used in manufacturing with emphasis on materials aspects. Introduction to the basic processes listed, how to best utilize the various techniques available, and how the properties of materials effect manufacturability. The course balances the fundamental aspects of materials processing with descriptive content regarding traditional forms of manufacturing.

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

*Delivery Method:* On-campus
*Potential Term Offered:* Fall
*Prerequisite:* MATH340 **&** MECH307
*Description:* Feedback and forward loop control design and simulation; discrete time and frequency domain methods with implementation considerations. (*Must register for lecture and laboratory).*
*Course Learning Objectives:*

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

**MECH 424 – Advanced Dynamics** **3 credits**

*Delivery Method:* On-campus
*Potential Term Offered:* Spring
*Prerequisite:* MECH324
*Description:* Dynamics is a very important aspect of mechanical engineering since it is the basis of so many areas (mechanisms, robotics, controls, solid mechanics, fluid mechanics, etc.). Therefore, it is important to be strong in dynamics as a mechanical engineer. MECH424 reviews basic kinematics and dynamics at an advanced level, explores 3-D mechanics and gyroscopic motion, and focuses on Lagrange energy methods for analyzing dynamics problems. The course is taught by Dr. Dave (his favorite to teach), and the class size is usually small. (*More information is available at http://www.engr.colostate.edu/~dga/mech424/)*

**MECH 425 – Mechanical Engineering Vibrations** **4 credits**

*Potential Term Offered:* Fall
*Prerequisite:* MECH324
*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

**MECH 431 – Metals and Alloys** **3 credits**

*Delivery Method:* On-campus & online section available
*Potential Term Offered:* Fall
*Prerequisite:* MECH331

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

**MECH 432 – Engineering of Nanomaterials 3 credits** *Potential Term Offered*: Fall (*even years*)
*Prerequisite*: MECH331
*Description*: Structure, properties, and processing of extremely small (10 to the minus 9 m) synthetic and natural materials.

**MECH 437 – Internal Combustion Engines 3 credits**
*Delivery Method:* On-campus
*Potential Term Offered:* Fall
*Prerequisite:* MECH344
*Description:* The purpose of the course is to apply the principles of thermodynamics, fluid mechanics, and heat transfer to better understand the behavior of internal combustion engines. The course will develop various thermodynamic cycles, analytical models of the combustion processes for spark and compression ignition engines, and the fluid flow associated with the intake, in-cylinder, and exhaust flow. Emissions, friction and heat transfer in engines will also be addressed. The course will include the use of MATLAB programs to model engine performance.
*Course Learning Objectives*:

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

**MECH 460 – Aeronautics 3 credits**
*Delivery Method:* On-campus
*Potential Term Offered:* Fall
*Prerequisite:* MECH342
*Description:* Thermodynamics and fluid mechanics principles applied to the mechanics, aerodynamics, performance, stability, and control of airplanes.
*Course Learning Objectives:*
Upon successful completion of this course, students should be able to

1. calculate airplane aerodynamics including lift and drag,
2. calculate airplane performance including maximum velocity, range and endurance, take-off and landing, 3. calculate airplane stability and control, and
4. calculate airplane propulsion (propeller, jet, and rocket)

**MECH 463 – Building Energy Systems 3 credits**
*Delivery Method:* On-campus
*Potential Term Offered*: Spring
*Prerequisite*: MECH344
*Description*: Comfort, psychometrics, loads, solar radiation, heating and cooling system design, transport, solar system design, economics. *Course Learning Objectives*:

1. To learn how to apply the fundamentals of thermal sciences (heat transfer, thermodynamics, fluid mechanics) to determine the environmental performance of buildings.
2. To learn how to model and compute building heating and cooling loads.

3. To learn how to calculate the performance of building HVAC equipment such as fans, diffusers, heat exchangers, and chillers/compressors.

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

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

**MECH 477 – Algorithms in Scientific Computing** **3 credits**
*Delivery Method:* On-campus
*Potential Term Offered:* Spring
*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.

**MECH480A5 - Vehicle Dynamics** **3 credits**
*Delivery Method:* On-campus
*Potential Term Offered:* Spring
*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
*Prerequisite:* MECH342
*Description:* Introduction to compressible fluid dynamics covering inviscid conservation laws, acoustic propagation, normal shock waves, oblique shock and expansion waves, quasi-one-dimensional flow, unsteady waves, and conical flow. *(Sections may be offered: Online).*

**MECH 481A3 – Materials Selection for Mechanical Design** **3 credits**
*Delivery Method:* On-campus
*Potential Term Offered:* Fall
*Prerequisite*: MECH 325 **&** MECH 331
*Description:* Understanding materials, their properties and behavior is fundamental to engineering design. The number of materials available to the engineer is vast: something between 40,000 and 80,000 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.

**MECH 481A4 – Green Engineering – Materials and Environment** **3 credits**
*Delivery Method:* On-campus **&** Online section available
*Potential Term Offered:* Fall*,* Spring
*Prerequisite:* MECH325 & MECH331
*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.

**MECH 481A5 – Fundamentals of Wind Energy** **3 credits**
*Delivery Method:* On-campus
*Potential Term Offered:* Fall, Spring, Summer (Online-Only)
*Prerequisite:* MATH261; CIVE260 **or** CIVE360 **or** MECH262
*Description:* This course aims to provide students with a fundamental knowledge of wind turbine operation, analysis, and design. The course will be used as an undergraduate elective in the College of Engineering. The course covers the topics wind resource prospecting, components of wind turbines, wind power conversion, annual energy production, aerodynamics of modern horizontal axis wind turbines, loads acting on horizontal axis wind turbines, electrical aspects of wind turbines, wind turbine siting, wind turbine controls, an introduction to the economics of wind power generation, and an introduction to design, wind turbine codes and standards. (*Sections may be offered: Online*). *Course Learning Objectives*:

1. Perform wind resource prospecting
2. Identify principal wind turbine components and their functions
3. Describe the concept of wind power conversion into electrical power
4. Calculate the annual energy production of a wind turbine and a wind farm
5. Explain the principles of wind turbine blade aerodynamics
6. Analyze components of blade aerodynamic forces

7. Calculate types and sources of loads applied on a wind turbine
8. Explain wind turbine siting and layout considerations
9. Identify electrical systems of a wind turbine and their principles of operation
10. Explain wind turbine grid integration
11. Identify wind turbine control systems and explain their operation
12. Estimate cost of wind power generation
13. Explain wind turbine design procedures, standards, testing, and certifications

## 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 **&** online section available
*Potential Term Offered*: Fall *(Online Only)*, Spring
*Prerequisite*: MECH202 **&** MECH331
*Description*: In this course, you will learn the importance of additive manufacturing (a.k.a. 3D Printing) and its huge role in global product development and innovation. You will develop a rich knowledge of 3D printing technologies, devices, capabilities, materials and applications. You will learn the trade-offs between various 3D printing processes and technologies, along with the various software tools, processes and techniques enabling personal fabrication, such as 3D scanning. You will explore the broad range of 3D printing applications, including biomedical, aerospace, consumer products, and creative artistry, to mention a few. Finally, you will learn the latest trends and opportunities in 3D printing, including "personal" 3D printing, localized services, production parts, mass customization, and how to commercialize your ideas. (*Sections may be offered: Online. To view online credit courses, please see the following link: https://www.online.colostate.edu/courses/credit).*

**MECH 505 – Stream Power Plants** **3 credits**

*Potential Term Offered:* Spring
*Prerequisite:* MECH344
*Description*: Technology review and application of engineering sciences and economics to the analysis and design of vapor power generation systems. Vapor power cycles, steam generation, and auxiliary systems associated with power plants. Overall design of power plants as well as component design. Fossil fuel and nuclear energy systems are considered.
*Course Learning Objectives:*

1. Apply thermodynamic principles to real-world power generation.
2. Recognize and describe central-power-station equipment.
3. Identify the economic issues of power generation.
4. Demonstrate capability to design and optimize power plant systems.
5. Prepare for advanced courses in Thermodynamics, Thermal Systems, and Combustion.

**MECH 507 – Laser Diagnostics for Thermosciences** **3 credits**

*Delivery Method:* On-campus
*Potential Term Offered*: Spring (*odd years*)
*Prerequisite*: PH142
*Description*: Basics of optics, spectroscopy, and lasers. Physics and applications of laser diagnostic techniques used in Thermosciences.

**MECH 511 – Engineering Decision Making under Uncertainty (*Online only*)** **3 credits**

*Potential Term Offered*: Spring

*Prerequisite*: MECH410 **&** STAT315
*Description*: You will learn to apply advanced systems engineering and engineering economic methodologies and advanced financial analysis concepts to real world capital allocation decision making in government, the military, and the service and manufacturing industries. Topics include continuous compounding, capital budgeting models, capital rationing, lending and borrowing, business and engineering measures of worth, costs of delay, multicriteria optimization, utility theory, risk assessment, risk attitudes, catastrophic business risk (risk of ruin), preference and ordering rules, advanced financial and engineering concepts, certainty equivalence, value determination, value of information, business and Engineering measures of worth, stochastic dominance, portfolio theory, simulation, decision tree analysis, sensitivity analysis, certainty equivalents, and replacement analysis.

**MECH 513 – Simulation Modeling and Experimentation** **3 credits**
*Delivery Method:* On-campus **&** Online section available *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 semiweekly 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.

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

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

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

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

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

**MECH 525 – Cell and Tissue Engineering** **3 credits**

*Delivery Method:* Online
*Potential Term Offered:* Fall
*Prerequisite*: BC351 **or** BMS300 **or** BMS500 **or** BZ310 **or** NB501
*Description*: This course is designed to familiarize current and future researchers with tissue engineering concepts and current practice. Topics covered include: tissue morphogenesis and homeostasis, stem cells, cell signaling, cell nutrition, cryopreservation, biomaterials, tissue engineering scaffolds, biocompatibility and ethics. *(Sections may be offered: Online).*
*Course Learning Objectives:*
Upon the completion of this course, you should be able to:

1. Understand the paradigms of tissue engineering and regenerative medicine.
2. Develop a more complete understanding of cell biology, development and tissue repair. Improve knowledge of mechanical and chemical properties of biomaterials.
3. Develop an understanding of current challenges in the field of tissue engineering.

**MECH 526 – Fundamentals of Vehicle Dynamics** **3 credits**

*Delivery Method:* On-campus
*Potential Term Offered*: Spring
*Prerequisite*: MECH324
*Description*: Kinetics of vehicle suspensions, steady state and transient stability and control, tires, wheel and suspension geometry and loads, dampers, steering.

**MECH 527 – Hybrid Electric Vehicle Powertrains** **3 credits**

*Delivery Method:* On-campus
*Potential Term Offered*: Fall
*Prerequisite*: MECH307

*Description*:

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

**MECH 529 – Advanced Mechanical Systems (*Online only*) 3 credits**

*Delivery Method:* On-campus & online section available

*Potential Term Offered*: Fall

*Prerequisite*: MECH307

*Description*: Modeling, analysis, and synthesis of practical mechanical devices in which dynamic response is dominant consideration.

*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:* CIVE360 **&** MECH331

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

**MECH 531 – Materials Engineering 3 credits**

*Delivery Method:* On-campus & online section available

*Potential Term Offered:* Spring

*Prerequisites:* MECH331 **&** MECH431

*Description*: Selection of structural engineering materials by properties, processing, and economics; materials for biomedical and biotechnology applications. *(Sections may be offered: Online).*

**MECH 532 – Materials Issues in Mechanical Design 3 credits** *Delivery Method:* On-campus & online section available

*Potential Term Offered*: Fall

*Prerequisite*: MECH331

*Description*: Failure mechanisms from materials viewpoint with emphasis on use in design. Fracture, creep, fatigue, and corrosion. *(Sections may be offered: Online).*

*Description*:

**MECH 533 – Composites Product Development** **3 credits**

*Delivery Method:* On-campus

*Potential Term Offered*: Fall

*Prerequisites*: MECH331 **&** CIVE360

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:* MECH337

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

**MECH 538 – Mechanical Engineering Thermodynamics** **3 credits**

*Delivery Method:* On-campus

*Potential Term Offered*: Fall

*Prerequisite*: MECH337

*Description*: First and second laws of thermodynamics applied to engineering devices and systems. Introduction to availability, energy, and lost work analysis.

**MECH 539 – Advanced Fluid Mechanics** **3 credits**

*Potential Term Offered:* Fall

*Prerequisite:* CIVE300 **or** MECH342

*Description*: Development of the three-dimensional, unsteady, governing equations for describing the mo-tion of inviscid and viscous compressible fluids; differential and integral forms of the equations; constitutive equations for a compressible fluid; the entropy equation; compressible boundary lay-ers; area-averaged equations for onedimensional steady flow; shock waves; channel flow with heat addition and friction; flow in nozzles and inlets; oblique shock waves; Prandtl-Meyer expansion; unsteady one-dimensional flow; the shock tube; acoustics in onedimension; steady flow in two-dimensions; potential flow; linearized potential flow; lift and drag of thin airfoils. Upon completion of this course, students will be equipped with theories and analytical meth-ods for furthering studies on compressible flow with more general flow geometry and real gas effects.

**MECH 543 – Biofluid Mechanics** **3 credits**

*Delivery Method:* On-campus & online section available

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

*Prerequisites*: MECH342 **or** CIVE300 **or** BMS300 **&** PH121 **or** BMS300 **&** PH141 **or** BMS420

*Description*: The course will focus on biotransport concepts for understanding transport in and created by living organs/organisms with a focus on fluid mechanics and cardiovascular flow. Upon completing this course, the

*Description*:
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:* MECH344

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:* MECH342
*Description:* Characteristics of real gases in reacting and nonequilibrium systems; equilibrium air; statistical mechanics, chemical thermodynamics.

**MECH 552 – Applied Computational Fluid Dynamics** **3 credits**

*Delivery Method:* On-campus
*Potential Term Offered*: Fall (*odd years*)
*Prerequisite*: CIVE300 **or** CBE331 **or** MECH342
*Description*: The course objective is to learn how to use a CFD program (ANSYS Fluent) intelligently to solve fluid related problems accurately. To achieve this objective, you will study:

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

**MECH 557 – Turbomachinery** **3 credits**

*Delivery Method:* On-campus
*Potential Term Offered*: Spring

*Description*:
*Prerequisite*: MECH337 **&** MECH342
*Description*: Application of fundamental principles of thermodynamics and fluid mechanics to turbomachinery.

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

**MECH 564 – Fundamentals of Robot Mechanics and Controls** **3 credits**
*Delivery Method:* On-campus
*Potential Term Offered:* Spring
*Prerequisite***:** MECH417

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*: MATH340
*Description*: Physical processes in broad-beam electron-bombardment ion sources for space propulsion and ion machining applications.

**MECH 568 – Computational Methods for Mechanical Engineering** **3 credits** *Delivery Method:* On-campus
*Potential Term Offered*: Fall
*Prerequisites*: MATH450 **or** MATH451
*Description*: Fundamental principles, which provide the foundation for the software and algorithms used in Mechanical Engineering.

**MECH 569 – Micro-Electro-Mechanical Devices** **3 credits**
*Delivery Method:* On-campus
*Potential Term Offered*: Spring
*Prerequisite*: MECH344 *with a minimum grade of C* **or** ECE 331 *with a minimum grade of C*
*Description*: This technology combines mechanical and electrical engineering systems on a silicon chip for: Body area networks dedicated sports monitors, medical diagnostics and to monitoring health, instant lab on a chip blood analysis for disease markers, ink jet printing of 3D body parts, human DNA analysis on a chip for under $1000. In addition, pico projection displays now available for augmented reality assistance in medical procedures. Finally, $3 cost for accelerometers, gyroscopes enable hand gestures to be read electronically in order to control medical devices. This course also impacts new microfluidic applications such as: lab on a chip biotechnology to determine blood glucose levels, even DNA, from bodily fluids in real time for again 1/1000 the cost of prior methods allowing personalized medicine, low cost medical diagnostics, and new means of drug delivery, such as

*Description*:
insulin, directly to areas of the body using micro fluidic delivery to mention but a few new commercial products. All are systems on chip (SOC) low cost solutions to real problems. It is an exciting time to learn about MEMS, progress to date and future capabilities.

**MECH 570 – Bioengineering** **3 credits**

*Delivery Method:* On-campus & online section available
*Potential Term Offered*: Spring
*Prerequisites*: MECH307 **&** MECH324
*Description*: Physiological and medical systems analysis using engineering methods including mechanics, fluid dynamics, control, electronics, and signal processing. *(Sections may be offered: Online).*

**MECH 573 – Structure and Function of Biomaterials** **3 credits**

*Delivery Method:* Online
*Potential Term Offered:* Spring
*Prerequisite:* MECH331
*Description:* A traditional mechanical engineering approach is used to explore the structure-function relationships of natural biomaterials that is then applied to the analysis of synthetic bio-inspired and biomimetic materials. The main focus is on structure/function relationships of materials. There is also emphasis on mechanical design and function, with some discussion of cellular interactions. Materials covered include skin, horn, nail, hoof, hair,

wood, plants, spider silk, nacre, bone, tendon, ligament, cartilage, meniscus, and tissue engineering scaffolds. Topics for bio-inspired and biomimicked materials include structural materials like fiber-reinforced cements and polymers, and biomedical materials for clinical applications.

**MECH 574 – Bio-Inspired Surfaces** **3 credits**

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

**MECH 575 – Solar and Alternative Energies** **3 credits**

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

**MECH 576 – Quantitative Systems Physiology** **3 credits**

*Delivery Method:* On-campus & online section available
*Potential Term Offered*: Spring
*Prerequisites*: BMS300 **&** CHEM113 **&** MATH340 **&** PH142
*Description*: The course provides a quantitative understanding of functions of human organs, their interconnections and underlying cellular and molecular aspects that drive such functions. Expand knowledge on research into the health/biomedical-related arenas. (*Sections may be offered: Online*).

**MECH 577 – Aerosol Physics and Technology** **3 credits**

*Delivery Method:* On-campus
*Potential Term Offered:* Spring (*odd years*)
*Prerequisite:* PH141
*Description*: Aerosols and their applications in science and engineering, air pollution control, atmospheric science, and public health. Topics cover the physical and chemical principles underlying the behavior of particles suspended in air, including particle size, aerodynamics, motion of particles in a force field, particle size statistics, and optical and electrical properties. (*Senior standing. Sections may be offered: Online).*
*Course Learning Objectives:*
Upon completing this course, students will be able to (1) describe particle properties that are relevant for aerosol behavior and measurement, (2) describe the fundamental forces that govern aerosol transport, (3) employ stateof-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:* CIVE360
*Description:* Application of engineering concepts to quantify the mechanical behavior of load-bearing biological tissues and orthopaedic implant performance.

**MECH579 – Cardiovascular Biomechanics** **3 credits**
*Delivery Method:* On-campus and online section available
*Potential Term Offered:* Fall
*Prerequisite:* MATH340 & PH142
*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.

**MECH580B1 – Industrial Gas and Dual-Fuel Engines** **3 credits**
*Delivery Method:* On-campus
*Potential Term Offered:* Fall
*Prerequisite*: MECH237 **or** MECH337
*Description:* These engineering marvels of extreme power density, efficiency, and durability are the power of choice for electric power and gas compression. They are also a critical green technology for future petroleum development, petroleum production, rail, mining, and marine applications. Students will gain a strong fundamental understanding of engine components, thermodynamics, and economics of the industrial engine business from the world leader in industrial natural gas engine technology.

**MECH581A7 – Thermal Energy Systems Design and Analysis** **3 credits** *Delivery Method:* On-campus
*Potential Term Offered*: Fall
*Prerequisite*: MECH 344
*Description:* Concepts, laws, and methodologies of thermodynamics, fluid mechanics, and heat transfer and application to the design and analysis of practical and advanced thermal energy systems. Graduate standing.

**MECH581A9 – Processing of Polymer Composites** **3 credits**
*Delivery Method:* On-campus
*Potential Term Offered*: Spring
*Prerequisite*: CIVE 360 **&** MECH 331.

*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.

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

## Alternate Technical Electives:

**BIOM 382 – Study Abroad: Prosthetics in Ecuador** **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.

**BMS 300 – Principles of Human Physiology** **4 credits**

*Potential Term Offered*: Fall, Spring, Summer

*Prerequisite*: BZ101 or BZ110 or LIFE102 **&** CHEM103 or CHEM107 or CHEM111 *Description*: Physiology of humans.

**CON 450 –Travel Abroad – Sustainable Buildings** **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 150 – Culture in Coding *** **3 credits**

*Potential Term Offered*: Fall, Spring *Prerequisite*:
N/A.
*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 a basic programming language. Students will be expected to write small programs, and construct written arguments on ways in which technology influences our modern culture. Previous computer science experience not necessary. ****This course will satisfy AUCC3B and ALT Technical Elective credits***

**CS 163 – Java (CS1) No Prior Programming** **4 credits**

*Potential Term Offered*: Fall, Spring, Summer
*Prerequisite*: MATH124 with a minimum grade of C
*Description*: Computer programming in Java for students without previous programming experience. Topics include variables, assignment, expressions, operators, booleans, conditionals, characters and strings, control loops, arrays, objects and classes, file input/output, interfaces, recursion, lists, and sorting. *(Must register for lecture and laboratory)*.

**CS 164 – Java (CS1) Prior Programming** **4 credits**

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

**CIVE 367 – Structural Analysis** **3 credits**

*Potential Term Offered*: Fall, Spring *Prerequisite*:
CIVE360
*Description*: Determination of actions in and deformations of determinate and indeterminate structures.

**CIVE 438 – Environmental Engineering Concepts** **3 credits**

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

**ECE 411 – Control Systems** **4 credits**

*Potential Term Offered*: Fall
*Prerequisite***:** ECE312 with a minimum grade of C
*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*: ECE202 with a minimum grade of C

*Description*: Various electrical energy generation alternatives. Comparisons based on cost, reliability, availability and environmental impact.

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

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

**IDEA 310E – Design Thinking Toolbox: Wood 2 credits**
*Potential Term Offered*: Spring
*Prerequisite*: IDEA210 *(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.

**IDEA 310F – Textiles 1 credit**
*Potential Term Offered*: Spring
*Prerequisite*: IDEA210 *(may be taken concurrently)*
*Description*: Employ design theories and methods to textile projects that promote "iterative tinkering" through exploration of various design processes in a maker space setting.

*Course Learning Objectives:*
Upon successful completion of this course students will be able to:
1. Articulate compelling page layout, concept boards, portfolios and presentations
2. Demonstrate the understanding of various textile weaves, knit structures, and prints

**IDEA 310G – Infographics 1 credit**
*Potential Term Offered*: Spring
*Prerequisite*: IDEA210 *(may be taken concurrently)*
*Description*: This course will develop a broad overview and understanding of the visual display of information and data. The following goals articulate the general objectives and purpose of this course:
• Define the benefits and characteristics of clear presentation of data
• Demonstrate a knowledge of techniques for creating graphic elements and illustrations using vector graphics
• Gain an awareness of creating clear and meaningful information design

• Students will research, obtain, clarify, ideate, and present various groups of data and information through a variety of means and visual tools.

**MATH 331 – Introduction to Mathematical Modeling** **3 credits**
*Potential Term Offered*: Fall
*Prerequisite*: MATH161 *(may be taken concurrently)* **&** MATH229 *(may be taken concurrently)* **or** MATH369 *(may be taken concurrently)*
*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** MATH345
*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*: MATH161 **or** MATH255 **or** MATH271
*Description*: Linear systems, matrices, subspaces of Euclidean spaces, linear transformations on Euclidean spaces, eigenvalues, and eigenvectors.

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

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

**MKT 305 – Fundamentals of Marketing** **3 credits**
*Potential Term Offered:* Fall, Spring, Summer
*Prerequisites:* AREC202 **or** ECON101 **or** ECON202
*Description:* Overview of marketing activities involved in provision of products and services to consumers, including target markets and managerial aspects.

**PH 314 – Introduction to Modern Physics** **4 credits** *Potential Term Offered:* Spring
*Prerequisites:* MATH261 *(may be taken concurrently)* **&** PH142
*Description:* Relativity; quantum mechanics; atomic structure; applications to solid-state, nuclear, and elementary particle physics.

**PH 341 – Mechanics** **4 credits**
*Potential Term Offered:* Fall

*Prerequisites:* MATH340 **or** MATH345 **&** PH142
*Description:* Particle dynamics, translation and rotation of rigid bodies, moving coordinate systems, Lagrangian mechanics, matrix and tensor methods.

**PH 353 – Optics and Waves** **4 credits**
*Potential Term Offered*: Fall
*Prerequisites*: MATH261 **&** PH142
*Description*: Geometrical optics; wave optics; interference, diffraction, and polarization; quantum optics.

**PH 451 – Introductory Quantum Mechanics l** **3 credits**
*Potential Term Offered:* Fall
*Prerequisite:* MATH340 **or** MATH345 **&** PH314
*Description:* Schrodinger's theory of wave mechanics, potential wells, harmonic oscillators, wave packets, operators, angular momentum.

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

**ENGR/ECE 501 – Foundations of Systems Engineering** **3 credits** *Potential Term Offered*: Fall, Spring
*Prerequisite*: N/A
*Description:* Functional components of systems engineering, application of systems engineering to practical problems, system life-cycle process. (*Sections may be offered: Online*)

**CIVE 504 – Wind Engineering** **3 credits**
*Potential Term Offered*: Fall
*Prerequisite*: CIVE300
*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*: CIVE360
*Description*: Analysis of stress and strain failure theory; selected topics in solid mechanics, plate analysis; introduction to elastic stability. (*Sections may be offered: Online*).

**CIVE 562 – Fundamentals of Vibrations** **3 credits**
*Potential Term Offered*: Spring
*Prerequisite*: CIVE261 **&** CIVE360
*Description*: Free and forced vibrations of single, two, and multiple degree of freedom systems. Closed-form and numerical solutions. (*Sections may be offered: Online*).

## Other Interesting Courses

**ENGR 300 – 3D Printing Lab for Engineers** **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 <u>not</u> fulfill a MECH Technical Elective *or* an Alternate Technical Elective requirement.**