

# ENGINEERING (ENGR)

## ENGR 10005 INTRODUCTION TO CYBERSECURITY 3 Credit Hours

This course introduces students to the fundamentals of computer technology and cybersecurity. Students develop an understanding of computer hardware and software, cybercrime, security principles, technologies and procedures used to defend networks. This course also explores cyber trends, threats and personal privacy.

**Prerequisite:** None.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

## ENGR 11000 INTRODUCTION TO ENGINEERING 3 Credit Hours

An introductory course in engineering covering topics including introductory topics in what it means to be an engineer. Additional topics include introductions to engineering standards, statistics, technical writing and communication, significant figures, and engineering problem solving. Students also learn about working in teams and managing a project and utilize the concepts learned in a semester long team design project.

**Prerequisite:** Minimum 67 ALEKS math score or a minimum C grade in either MATH 10675 or MATH 10775 or MATH 11010.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

## ENGR 11001 INTRODUCTION TO ENGINEERING 2 Credit Hours

An introductory course in engineering covering topics including introductory topics in what it means to be an engineer. Additional topics include introductions to engineering standards, statistics, technical writing and communication, significant figures and engineering problem solving. Students also learn about working in teams and managing a project and utilize the concepts learned in a semester long team design project.

**Prerequisite:** Minimum C- grade in the following courses: MATH 10675 or MATH 10775 or MATH 11010; or a pre/co-requisite of MATH 11022 or MATH 12002 or MATH 12011; or minimum 67 ALEKS math score.

**Corequisite:** ENGR 11002.

**Schedule Type:** Lecture

**Contact Hours:** 2 lecture

**Grade Mode:** Standard Letter

## ENGR 11002 INTRODUCTION TO ENGINEERING LABORATORY 1 Credit Hour

An introductory course in engineering covering topics including introductory topics in what it means to be an engineer. Additional topics include introductions to engineering standards, statistics, technical writing and communication, significant figures and engineering problem solving. Students also learn about working in teams and managing a project and utilize the concepts learned in a semester long team design project.

**Prerequisite:** Minimum C- grade in the following courses: MATH 10675 or MATH 10775 or MATH 11010; or a pre/co-requisite of MATH 11022 or MATH 12002 or MATH 12011; or minimum 67 ALEKS math score.

**Corequisite:** ENGR 11001.

**Schedule Type:** Laboratory

**Contact Hours:** 2 lab

**Grade Mode:** Standard Letter

## ENGR 13585 COMPUTER AIDED ENGINEERING GRAPHICS 3 Credit Hours

Introduction to 3D computer aided engineering graphics. Students will be able to create 3-D models and assemblies using a feature based parametric solid modeling CAD package. Students will learn concepts of engineering graphics as well as learn to generate, edit, and dimension drawing views.

**Prerequisite:** None.

**Schedule Type:** Laboratory, Lecture, Combined Lecture and Lab

**Contact Hours:** 1 lecture, 4 lab

**Grade Mode:** Standard Letter

## ENGR 13586 COMPUTER AIDED DESIGN I 2 Credit Hours

Introduction to 3D computer-aided design (CAD). Students create 3D models and assemblies using a feature-based parametric solid modeling CAD package. Students learn concepts of engineering graphics as well as learn to generate, edit and dimension drawing views. Students are required to bring their own portable computer.

**Prerequisite:** None.

**Corequisite:** ENGR 13587.

**Schedule Type:** Lecture

**Contact Hours:** 2 lecture

**Grade Mode:** Standard Letter

## ENGR 13587 COMPUTER AIDED DESIGN I LABORATORY 1 Credit Hour

Introduction to 3D computer-aided design (CAD). Students create 3D models and assemblies using a feature-based parametric solid modeling CAD package. Students learn concepts of engineering graphics as well as learn to generate, edit and dimension drawing views. Students are required to bring their own portable computer.

**Prerequisite:** None.

**Corequisite:** ENGR 13586.

**Schedule Type:** Laboratory

**Contact Hours:** 2 lab

**Grade Mode:** Standard Letter

## ENGR 15300 INTRODUCTION TO ENGINEERING ANALYSIS USING MATLAB® 2 Credit Hours

Introduction to basic concepts in engineering analysis using the Matlab® computing language, the industry-standard "first language" for engineers. Introduction to algorithm coding and development, debugging, analysis and interpretation. Students are required to bring their own portable computer and purchase the software for the course.

**Prerequisite:** Minimum C- grade in the following courses: MATH 10675 or MATH 10775 or MATH 11010; or a pre/co-requisite of MATH 11022 or MATH 12002 or MATH 12011; or minimum 67 ALEKS math score.

**Corequisite:** ENGR 15301.

**Schedule Type:** Lecture

**Contact Hours:** 2 lecture

**Grade Mode:** Standard Letter

## ENGR 15301 INTRODUCTION TO ENGINEERING ANALYSIS USING MATLAB® LAB 1 Credit Hour

Laboratory session introducing basic concepts in engineering analysis using the Matlab® computing language, the industry-standard "first language" for engineers. Introduction to algorithm coding and development, debugging, analysis and interpretation.

**Corequisite:** ENGR 15300.

**Schedule Type:** Laboratory

**Contact Hours:** 2 lab

**Grade Mode:** Standard Letter

**ENGR 20000 PROFESSIONAL DEVELOPMENT IN ENGINEERING 1 Credit Hour**

Providing several direct opportunities for interviewing and networking with engineering industry professionals, the main goal of this course is to prepare students for internship and career opportunities. Students will also have opportunities to develop necessary financial literacy skills to succeed in post-graduate careers while detailing and implementing short, middle and long-term life goals as part of the life-long learning process.

**Prerequisite:** Sophomore standing.

**Schedule Type:** Lecture

**Contact Hours:** 1 lecture

**Grade Mode:** Standard Letter

**ENGR 20002 MATERIALS AND PROCESSES 3 Credit Hours**

Study and practice addressing the nature of basic manufacturing materials and the processes by which they are converted into manufactured products. Includes laboratory experience.

**Prerequisite:** None.

**Schedule Type:** Laboratory, Lecture, Combined Lecture and Lab

**Contact Hours:** 2 lecture, 4 lab

**Grade Mode:** Standard Letter

**ENGR 21020 SURVEY OF ELECTRICITY AND ELECTRONICS 3 Credit Hours**

Survey of DC and AC circuits, semiconductors and electronic devices, including microprocessors and embedded systems.

**Prerequisite:** PHY 13002 or PHY 23102.

**Corequisite:** ENGR 21022.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 21022 SURVEY OF ELECTRICITY AND ELECTRONICS LABORATORY 1 Credit Hour**

Laboratory experiments related to the course ENGR 21020.

**Prerequisite:** PHY 13002 or PHY 23102.

**Corequisite:** ENGR 21020.

**Schedule Type:** Laboratory

**Contact Hours:** 2 lab

**Grade Mode:** Standard Letter

**ENGR 23010 COMPUTER HARDWARE 3 Credit Hours**

Introduction to the hardware, architecture and operation of the personal computer and associated devices. Topics include personal computer architecture and operation fundamentals; basic hardware; data buses and ports; hardware component packaging; auxiliary hardware components; computer assembly; basic hardware installation and configuration; and basic troubleshooting. This course is aligned with A+ content. CompTIA A+ is the preferred qualifying credential for technical support and IT operational roles.

**Prerequisite:** ENGR 10005.

**Schedule Type:** Laboratory, Lecture, Combined Lecture and Lab

**Contact Hours:** 2 lecture, 2 lab

**Grade Mode:** Standard Letter

**ENGR 23585 COMPUTER AIDED DESIGN II 3 Credit Hours**

Advanced applications of 3D, feature based, parametric, solid modeling software including finite element analysis, simulation, parameters, motion and mechanisms and other advanced tools in the design of parts and assemblies.

**Prerequisite:** ENGR 13585 or (ENGR 13586 and ENGR 13587).

**Schedule Type:** Laboratory, Lecture, Combined Lecture and Lab

**Contact Hours:** 1 lecture, 4 lab

**Grade Mode:** Standard Letter

**ENGR 25200 STATICS 3 Credit Hours**

Forces and moments; equilibrium in two and three dimensions; multi-force members; equilibrium, centroids and friction.

**Prerequisite:** MATH 12002 and PHY 23101 with a minimum C grade.

**Pre/corequisite:** ENGR 11000 or (ENGR 11001 and ENGR 11002).

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 25400 DYNAMICS 3 Credit Hours**

Kinematics and kinetics of rigid bodies in planar motion, including force and acceleration, work and energy and impulse and momentum. Introduction to the kinematics and kinetics of rigid bodies in three-dimensional motion.

**Prerequisite:** ENGR 25200; and MATH 22005 or MATH 32051.

**Pre/corequisite:** ENGR 11000 or (ENGR 11001 and ENGR 11002).

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 25500 AERODYNAMICS FOR ENGINEERS I 3 Credit Hours**

Basic fluid dynamics concepts, conservation laws, potential, airfoil and wing analysis. Boundary layers on plates and airfoils. Pressure gradients. Introduction to turbulent and vortex-dominated flows.

**Prerequisite:** ENGR 25200; and MATH 22005 or MATH 32051.

**Pre/corequisite:** ENGR 11000 or ENGR 15500.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 26220 PROGRAMMING FOR ENGINEERS 2 Credit Hours**

Introduction to engineering problem solving and use of programming language to solve those problems. Students are expected to develop basic mathematical modeling and engineering problem solving skills using mathematical tools and programming languages. Developing modeling and logical thinking are core objectives of this course. This course provides students with the required programming skills to work with embedded systems. Students are required to bring their own College of Aeronautics and Engineering (CAE) approved laptop. Specifications can be found on the CAE website.

**Prerequisite:** Sophomore standing.

**Corequisite:** ENGR 26222.

**Schedule Type:** Lecture

**Contact Hours:** 2 lecture

**Grade Mode:** Standard Letter

**ENGR 26222 PROGRAMMING FOR ENGINEERS LABORATORY 1 Credit Hour**

Lab to accompany ENGR 26220. Introduction to engineering problem solving and use of programming language to solve those problems. Students are expected to develop basic mathematical modeling and engineering problem solving skills using mathematical tools and programming languages. Developing modeling and logical thinking are core objectives of this course. This course provides students with the required programming skills to work with embedded systems. Students are required to bring their own College of Aeronautics and Engineering (CAE) approved laptop. Specifications can be found on the CAE website.

**Prerequisite:** Sophomore standing.

**Corequisite:** ENGR 26220.

**Schedule Type:** Laboratory

**Contact Hours:** 2 lab

**Grade Mode:** Standard Letter

**ENGR 26305 NETWORKING I 2 Credit Hours**

A hands-on, applied engineering-focused course emphasizing the operation, maintenance and performance aspects of personal computer networking hardware. Topics include networking hardware operation, characteristics, configuration and troubleshooting fundamentals. Course also includes network standards, protocols, configuration, topologies and administrative fundamentals as related to networking hardware systems.

**Prerequisite:** None.

**Corequisite:** ENGR 26306.

**Schedule Type:** Lecture

**Contact Hours:** 2 lecture

**Grade Mode:** Standard Letter

**ENGR 26306 NETWORKING I LABORATORY 2 Credit Hours**

A hands-on, applied engineering-focused course emphasizing the operation, maintenance and performance aspects of personal computer networking hardware. Topics include networking hardware operation, characteristics, configuration and troubleshooting fundamentals. Course also includes network standards, protocols, configuration, topologies and administrative fundamentals as related to networking hardware systems.

**Prerequisite:** None.

**Corequisite:** ENGR 26305.

**Schedule Type:** Laboratory

**Contact Hours:** 4 lab

**Grade Mode:** Standard Letter

**ENGR 27100 FUNDAMENTALS OF OPERATING SYSTEMS FOR ENGINEERING 3 Credit Hours**

The course will prepare students to engineer, install, monitor and manage systems using open-source operating systems. The students will learn operating system fundamentals for engineering applications, including cybersecurity engineering applications. Students will also learn how to configure local storage, create and configure systems, deploy and maintain systems, manage users and groups, and manage security. Different types of open source operating systems that are relevant for engineering systems will be introduced to students, in conjunction with key tools used in cybersecurity engineering.

**Prerequisite:** None.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 27210 INTRODUCTION TO SUSTAINABILITY 3 Credit Hours**

Introduces students to the concepts of sustainability and its three pillars, namely, economic growth, environmental protection and social equality. Students taking the course understand the language and concepts of sustainability and acquire the knowledge to further study sustainability.

**Prerequisite:** None.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 30001 APPLIED THERMODYNAMICS 3 Credit Hours**

Study of basic thermodynamic laws and how they apply to engineering applications. Topics include energy, entropy, enthalpy, heat engines and refrigerators. Introductory fluid mechanics, including Bernoulli's equation. Introductory heat transfer including conduction, convection and radiation.

**Prerequisite:** PHY 13001 or PHY 23101; and junior standing.

**Pre/corequisite:** ENGR 11000 or (ENGR 11001 and ENGR 11002).

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 31000 CULTURAL DYNAMICS TECHNOLOGY (DIVD) (WIC) 3 Credit Hours**

This course provides a comprehensive exploration of how technology profoundly shapes and is shaped by society. It delves into the intricate relationship between technology and society, offering students a nuanced perspective on the cultural dynamics of technological change within an engineering context. Students explore how technology significantly influences, reflects and coevolves with society by analyzing a wide range of topics from genetic engineering and economic systems to communication infrastructure and governance, all within the framework of engineering practices and principles.

**Prerequisite:** ENG 21011.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**Attributes:** Diversity Domestic, Writing Intensive Course

**ENGR 31010 ENGINEERING AND PROFESSIONAL ETHICS 3 Credit Hours**

Applications of codes of ethics in the engineering and technology professions reflective of social and moral responsibilities to the public, and accountability in engineering practice.

**Prerequisite:** None.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 31016 MANUFACTURING TECHNOLOGY 3 Credit Hours**

This course is designed to provide experience in, and an understanding of, the interrelationships of the major aspects of a manufacturing enterprise. The content of the course is oriented around the laboratory activities necessary to organize and operate an enterprise that will apply mass production techniques necessary to produce a product or service. During the course, the student will apply the concepts from lecture in the selection, designing, financing, production, marketing and distributing of a product or service.

**Prerequisite:** ENGR 20002.

**Schedule Type:** Laboratory, Lecture, Combined Lecture and Lab

**Contact Hours:** 2 lecture, 2 lab

**Grade Mode:** Standard Letter

**ENGR 31020 AUTOMATED MANUFACTURING 3 Credit Hours**

Theory and operation of computer controlled machine tools, robots and processes.

**Prerequisite:** None.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 31065 CAST METALS 3 Credit Hours**

Principles and processes of metal casting with a focus on current industrial practices. Includes laboratory experience with nonferrous metals and industrial tours.

**Prerequisite:** ENGR 20002.

**Schedule Type:** Laboratory, Lecture, Combined Lecture and Lab

**Contact Hours:** 5 other

**Grade Mode:** Standard Letter

**ENGR 33031 PROGRAMMABLE LOGIC CONTROLLERS 3 Credit Hours**

An introduction to programmable logic controllers (PLCS) covering hardware, ladder logic programming, networking and communications. Programming timers, counters and sequencers and an introduction to human machine interfaces (HMIS).

**Prerequisite:** (EERT 12000 and EERT 12001) or ENGR 21020 or ENGR 35500.

**Schedule Type:** Laboratory, Lecture, Combined Lecture and Lab

**Contact Hours:** 2 lecture, 2 lab

**Grade Mode:** Standard Letter

**Attributes:** ITAG Engineering Technology, TAG Engineering Technology

**ENGR 33032 PROGRAMMABLE LOGIC CONTROLLERS II 3 Credit Hours**

Advanced principles and applications of programmable logic controllers with a focus on using sequential function charts to control complex industrial processes. Includes real time control issues, PLC networking, programming languages other than ladder logic, standards, motion control, supervisory control and data acquisition, process control, alarm management, power failure strategies and safety.

**Prerequisite:** ENGR 33031.

**Schedule Type:** Laboratory, Lecture, Combined Lecture and Lab

**Contact Hours:** 2 lecture, 2 lab

**Grade Mode:** Standard Letter

**ENGR 33033 HYDRAULICS/PNEUMATICS 3 Credit Hours**

Fluid properties, hydraulic design, viscosity, hydraulic components, pumps, systems and circuits, maintenance and safety, pneumatics, air systems control and design.

**Prerequisite:** PHY 13001 or PHY 23101.

**Schedule Type:** Laboratory, Lecture, Combined Lecture and Lab

**Contact Hours:** 2 lecture, 2 lab

**Grade Mode:** Standard Letter

**ENGR 33041 CONTROL SYSTEMS 3 Credit Hours**

Design and analysis of feedback control systems. Course includes introduction to feedback control systems, open loop and closed loop control, Laplace transforms, control system models, static and dynamic response, stability and performance of control systems, root locus technique, frequency response analysis (Bode plot) and design of controller for feedback control systems.

**Prerequisite:** (EERT 12000 and EERT 12001) or ENGR 21020 or ENGR 35500; and MATH 12002 or MATH 12012.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 33092 COOPERATIVE EDUCATION - PROFESSIONAL DEVELOPMENT (ELR) (WIC) 1-3 Credit Hours**

(Repeatable for a maximum of 6 credit hours) Supervised work-study experience in approved business or industrial environment relative to the student's major. A 3 credit hour co-op experience must be for a period of at least 12 consecutive weeks at 40 hours per week, or 30 hours per week for 15 weeks, totaling not less than 450 hours. Most co-ops occur during the summer. Students can earn up to an additional 3 credit hours (one to three per co-op – 150 work hours per credit hour) over the course of their college career as long as each co-op has a different focus.

**Prerequisite:** Minimum 2.250 overall GPA; and sophomore standing; and special approval.

**Schedule Type:** Practical Experience

**Contact Hours:** 10-30 other

**Grade Mode:** Standard Letter-IP

**Attributes:** Experiential Learning Requirement, Writing Intensive Course

**ENGR 33111 STATICS AND STRENGTH OF MATERIALS 3 Credit Hours**

An algebra-based analytical study of equilibrium of extended two-dimensional bodies; the concepts of elastic and thermal properties of materials; centroid and moment of inertia; and the relationship between the external forces applied to extended objects (generally beams and columns) and the resulting bending and shear stresses, the resulting strains and deformation of the object.

**Prerequisite:** PHY 13001 or PHY 23101.

**Pre/corequisite:** ENGR 11000 or (ENGR 11001 and ENGR 11002).

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 33222 DIGITAL DESIGN FOR COMPUTER ENGINEERING 3 Credit Hours**

Introduction to digital design. The operation and use of digital devices and components as used in microprocessors and digital computers. Topics include binary arithmetic operations, Boolean algebra, logic gates, combinational and sequential logic, buffers, registers, memory devices. Students are exposed to applied problem solving via basic programming with microcontrollers and microprocessors.

**Prerequisite:** (EERT 12000 and EERT 12001) or ENGR 21020 or ENGR 35500.

**Schedule Type:** Laboratory, Lecture, Combined Lecture and Lab

**Contact Hours:** 2 lecture, 2 lab

**Grade Mode:** Standard Letter

**ENGR 33223 ELECTRONIC COMMUNICATION 3 Credit Hours**

Principles of digital and analog telecommunications and data signals. Topics include electromagnetic signal time and frequency characteristics, signal propagation, signal modulation, transmission lines, wireless signals, antennas, digital signal characteristics and protocols, signal multiplexing, microwave devices and applications.

**Prerequisite:** (EERT 12000 and EERT 12001) or (ENGR 21020 and ENGR 21022) or (ENGR 35500 and ENGR 35501).

**Schedule Type:** Laboratory, Lecture, Combined Lecture and Lab

**Contact Hours:** 2 lecture, 2 lab

**Grade Mode:** Standard Letter

**ENGR 33320 APPLIED EMBEDDED SYSTEMS I 3 Credit Hours**

Course teaches students to utilize embedded systems for engineering problem solving. Students are exposed to the history of the microcontroller that is at the heart of modern embedded systems. Students learn about the different classes of embedded systems and form a foundation from which they can begin to develop solutions to simple, but real-world, problems using simple embedded microcontrollers, electronic devices and sensors. Basic coding principles are explained from an engineering problem solving perspective.

**Prerequisite:** CS 13001 or CS 13012 or (ENGR 26220 and ENGR 26222); and (EERT 12000 and EERT 12001) or (ENGR 21020 and ENGR 21022) or (ENGR 35500 and ENGR 35501).

**Schedule Type:** Laboratory, Lecture, Combined Lecture and Lab

**Contact Hours:** 2 lecture, 2 lab

**Grade Mode:** Standard Letter

**ENGR 33334 INDUSTRIAL ROBOTICS 1 Credit Hour**

Classification, characteristics and functions of industrial robots. Covers basic safety precautions for working with robots. Laboratory time is spent programming FANUC industrial robots and utilizing FANUC robot teach pendants. Students have the opportunity to obtain a FANUC Robotics Handling Tool Operation and Programming certificate of completion.

**Prerequisite:** PHY 13002.

**Corequisite:** ENGR 33335.

**Schedule Type:** Lecture

**Contact Hours:** 1 lecture

**Grade Mode:** Standard Letter

**ENGR 33335 INDUSTRIAL ROBOTICS LABORATORY 1 Credit Hour**

Classification, characteristics and functions of industrial robots. Covers basic safety precautions for working with robots. Laboratory time is spent programming FANUC industrial robots and utilizing FANUC robot teach pendants. Students have the opportunity to obtain a FANUC Robotics Handling Tool Operation and Programming certificate of completion. This is the laboratory portion of the course.

**Prerequisite:** PHY 13002.

**Corequisite:** ENGR 33334.

**Schedule Type:** Laboratory

**Contact Hours:** 2 lab

**Grade Mode:** Standard Letter

**ENGR 33364 METALLURGY AND MATERIALS SCIENCE 3 Credit Hours**

Scientific study of modern manufacturing materials (metals, plastics and ceramics) with an emphasis on metals and the laboratory test methods, and data used to determine their manufacturing specifications and properties.

**Prerequisite:** Junior standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 33440 ELECTRONIC DEVICES 3 Credit Hours**

Introduction to electronic non-linear devices including diodes, transistors, optoelectronic devices and operational amplifiers. Use and application of these devices in different types of application like rectifiers, amplifiers and linear integrated circuits.

**Prerequisite:** (EERT 12000 and EERT 12001) or (ENGR 21020 and ENGR 21022) or (ENGR 35500 and ENGR 35501).

**Corequisite:** ENGR 33442.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 33442 ELECTRONIC DEVICES LABORATORY 1 Credit Hour**

Course is lab component for ENGR 33440. Lab materials mirror concepts learned in lecture, including the introduction to electronic non-linear devices (e.g., diodes, transistors, optoelectronic devices, operational amplifiers). Use and application of these devices in different types of application like rectifiers, amplifiers and linear integrated circuits.

**Prerequisite:** (EERT 12000 and EERT 12001) or (ENGR 21020 and ENGR 21022) or (ENGR 35500 and ENGR 35501).

**Corequisite:** ENGR 33440.

**Schedule Type:** Laboratory

**Contact Hours:** 2 lab

**Grade Mode:** Standard Letter

**ENGR 33657 INTRODUCTION TO LEAN SIX SIGMA 3 Credit Hours**

An introduction to lean six sigma. Including understanding the systems, measuring and defining performance, analyzing, improving, and controlling processes, and leading six sigma initiatives.

**Prerequisite:** MATH 11010.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 33700 QUALITY TECHNIQUES 3 Credit Hours**

Introduction to quality management and the tools and techniques including the basic tools identified by ASQ (American Society for Quality) as well as an introduction to Lean and Six Sigma. Information presented helps prepare the student to qualify for the Quality Process Analyst Certification.

**Prerequisite:** None.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 33870 FACILITY DESIGN AND MATERIAL HANDLING 3 Credit Hours**

Provides students with a fundamental understanding of how layout affects the flow through a system. Both qualitative and quantitative tools are presented for complete approach to facility design and material handling.

**Prerequisite:** Junior standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 35200 THERMAL FLUID ENGINEERING 3 Credit Hours**

First and Second Law of Thermodynamics for closed and open systems. Fundamentals of fluid mechanics and heat transfer.

**Prerequisite:** MATH 22005 or MATH 32051; and PHY 23101.

**Corequisite:** ENGR 35201.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 35201 THERMAL FLUID ENGINEERING LABORATORY 1 Credit Hour**

Laboratory demonstrations and experiments for various heat transfer and fluid dynamics concepts.

**Prerequisite:** None.

**Corequisite:** ENGR 35200.

**Schedule Type:** Laboratory

**Contact Hours:** 2 lab

**Grade Mode:** Standard Letter

**ENGR 35300 AIRCRAFT PERFORMANCE AND STABILITY I 3 Credit Hours**

First of a two-course sequence in aircraft performance and flight mechanics. Performance analysis of fixed-wing performance. Development of the aircraft equations of motion. Static stability analysis. Introduction to rotary-wing performance.

**Prerequisite:** ENGR 15300 and ENGR 15301; and MATH 32044 or MATH 32052; and ENGR 25400 and ENGR 25500 with a minimum C grade.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 35500 SIGNALS AND CIRCUITS 3 Credit Hours**

An introduction to electric circuit elements and electronic devices and a study of circuits containing such devices. Both analog and digital systems are considered.

**Prerequisite:** PHY 23102.

**Corequisite:** ENGR 35501.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 35501 SIGNALS AND CIRCUITS LABORATORY 1 Credit Hour**

Laboratory demonstrations and experiments for electrical circuits, data acquisition, and signal measurements.

**Corequisite:** ENGR 35500.

**Schedule Type:** Laboratory

**Contact Hours:** 2 lab

**Grade Mode:** Standard Letter

**ENGR 35550 LAW AND ETHICS FOR ENGINEERS 3 Credit Hours**

This course examines legal and ethical issues in engineering design. Special focus will be given to Negligence Law, Strict Product Liability Law, Design and Manufacturing defects, Patent, Copyright and Trademark law. Employment law and whistleblower protection will be discussed in the context of the engineer. Special focus will be given through the examination of case studies including but not limited to the Space Shuttle Challenger disaster, the Space Shuttle Columbia Disaster, the Boeing 737 Max crashes.

**Prerequisite:** None.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 35600 AERODYNAMICS FOR ENGINEERS II 3 Credit Hours**

Compressible flow relationships; compressibility effects on airfoil and wing aerodynamics; shock waves; boundary layer effects on aircraft performance.

**Prerequisite:** ENGR 25500; and MATH 32044 or MATH 32052.

**Pre/corequisite:** ENGR 35200.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 35765 QUALITY AND RELIABILITY ENGINEERING 3 Credit Hours**

Introduction to reliability and quality engineering with an emphasis on manufacturing and techniques for improving quality and reliability. Includes reliability, reliability prediction, quality techniques, modeling statistical process control, control charts, sampling, experimental design, and designing and manufacturing for quality and reliability.

**Prerequisite:** MATH 11010.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 36305 NETWORKING II 2 Credit Hours**

Continuation of ENGR 26305 and ENGR 26306. In-depth coverage of personal computer-based enterprise networking systems hardware with a focus on network hardware and software configuration, fault analysis, diagnostics and troubleshooting. Topics include router and switch operation, programming, configuration and troubleshooting, along with overall enterprise network maintenance, troubleshooting and repair. Course also includes WAN and VLAN fundamentals, intermediate TCP/IP and network administration and maintenance as related to fielding and maintaining networking hardware components and systems.

**Prerequisite:** ENGR 26305 and ENGR 26306.

**Corequisite:** ENGR 36306.

**Schedule Type:** Lecture

**Contact Hours:** 2 lecture

**Grade Mode:** Standard Letter

**ENGR 36306 NETWORKING II LABORATORY 1 Credit Hour**

Continuation of ENGR 26305 and ENGR 26306. In-depth coverage of personal computer-based enterprise networking systems hardware with a focus on network hardware and software configuration, fault analysis, diagnostics and troubleshooting. Topics include router and switch operation, programming, configuration and troubleshooting, along with overall enterprise network maintenance, troubleshooting and repair. Course also includes WAN and VLAN fundamentals, intermediate TCP/IP and network administration and maintenance as related to fielding and maintaining networking hardware components and systems.

**Prerequisite:** ENGR 26305 and ENGR 26306.

**Corequisite:** ENGR 36305.

**Schedule Type:** Laboratory

**Contact Hours:** 2 lab

**Grade Mode:** Standard Letter

**ENGR 36337 INFORMATION TECHNOLOGY SECURITY 3 Credit Hours**

This course provides the foundation for understanding the key issues associated with protecting information assets. It covers the essential principles for information security and risk management; making it an important stepping stone of an IT security career. The course is supported with case based industry problems and their solutions through simulation based labs. Additionally, this course prepares students for CompTIA's Security+ SY0-501 certification exam.

**Prerequisite:** ENGR 10005; and junior standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 36620 PROJECT MANAGEMENT IN ENGINEERING 3 Credit Hours**

The planning, organizing, directing and controlling of company technology resources for project-based management functions. Includes project coordination requirements, management and planning methods and the use of various management and planning tools.

**Prerequisite:** Junior standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 37777 CYBERSECURITY OPERATIONS 2 Credit Hours**

The course also aligns to the Cisco Certified CyberOps Associate certification and covers how to monitor, detect, and respond to cybersecurity threats, as outlined in the National Institute of Standards and Technology (NIST) Cybersecurity Framework. You will learn security concepts, security monitoring, host-based analysis, network intrusion analysis, and security policies procedures. This course also aligns with the National Initiative for Cybersecurity Education (NICE) Cybersecurity Workforce Framework to support consistent communication language for cybersecurity education, training, and workforce development.

**Prerequisite:** ENGR 26305 and ENGR 26306.

**Corequisite:** ENGR 37778.

**Schedule Type:** Lecture

**Contact Hours:** 2 lecture

**Grade Mode:** Standard Letter

**ENGR 37778 CYBERSECURITY OPERATIONS LABORATORY 1 Credit Hour**

Laboratory activities related to course ENGR 37777.

**Prerequisite:** ENGR 26305 and ENGR 26306.

**Corequisite:** ENGR 37777.

**Schedule Type:** Laboratory

**Contact Hours:** 2 lab

**Grade Mode:** Standard Letter

**ENGR 41065 SOLID MODELING AND SOLIDIFICATION SIMULATION 3 Credit Hours**

Introduction to casting simulation software with emphasis on projects related to design and filling of casting molds.

**Prerequisite:** ENGR 23585 and ENGR 31065.

**Schedule Type:** Laboratory, Lecture, Combined Lecture and Lab

**Contact Hours:** 2 lecture, 2 lab

**Grade Mode:** Standard Letter

**ENGR 42111 STRENGTH OF MATERIALS FOR ENGINEERS 3 Credit Hours**

(Slashed with ENGR 52111 and ENGR 72111) The mathematical study of how materials respond to external forces. Stress, strain, torsion; deformation of thin-walled pressure vessels, beams and columns; and an introduction to energy methods.

**Prerequisite:** ENGR 25200; and MATH 32044 or MATH 32052.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 42363 MATERIALS SELECTION IN DESIGN AND APPLICATIONS 3 Credit Hours**

Description and analysis of procedures for selecting appropriate materials for a particular mechanical design. The affect of processing on material properties, introduction to materials science for users of materials. Extensive case studies of materials selection and materials and sustainability.

**Prerequisite:** ENGR 20002; and ENGR 33111 or ENGR 42111.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 42410 ENGINEERING OPTIMIZATION 3 Credit Hours**

(Slashed with ENGR 52410 and ENGR 72410) This course will cover the theoretical foundations and present methods associated with the engineering optimization field, including: problem statement formulation; sensitivity methods; decomposition methods; Multidisciplinary Design Optimization (MDO) formulations; unconstrained and constrained 1-D and n-D search methods; and an introduction to heuristic search methods. Engineering optimization in the context of design of complex engineering systems will be discussed as well, with an emphasis on emerging techniques in the field.

**Prerequisite:** Junior or senior standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 42610 INDUSTRIAL ROBOTICS AND VISION SYSTEMS 1 Credit Hour**

Students learn how to program a FANUC industrial robot using the teach pendant. They also learn how to set up and use an industrial robot vision system. Students who successfully complete this course and the corequisite lecture will receive both FANUC Robotics Handling Tool Operation and Programming and FANUC V-iRVison Operation and Programming - 2D Certificates of Completion.

**Prerequisite:** PHY 13002 or PHY 23102; and senior standing.

**Corequisite:** ENGR 42611.

**Schedule Type:** Lecture

**Contact Hours:** 1 lecture

**Grade Mode:** Standard Letter

**ENGR 42611 INDUSTRIAL ROBOTICS AND VISION SYSTEMS LABORATORY 2 Credit Hours**

Students learn how to program a FANUC industrial robot using the teach pendant. They also learn how to set up and use an industrial robot vision system. Students who successfully complete this course and the corequisite lecture will receive both FANUC Robotics Handling Tool Operation and Programming and FANUC V-iRVison Operation and Programming - 2D Certificates of Completion.

**Prerequisite:** PHY 13002 or PHY 23102; and senior standing.

**Corequisite:** ENGR 42610.

**Schedule Type:** Laboratory

**Contact Hours:** 4 lab

**Grade Mode:** Standard Letter

**ENGR 42620 INDUSTRIAL AUTOMATION AND CONTROL 1 Credit Hour**

Course covers programmable logic controllers, variable frequency drive motor control, human machine interfaces and industrial networking.

**Prerequisite:** ENGR 21020 (and ENGR 21022) or ENGR 35500 (and ENGR 35501).

**Corequisite:** ENGR 42621.

**Schedule Type:** Lecture

**Contact Hours:** 1 lecture

**Grade Mode:** Standard Letter

**ENGR 42621 INDUSTRIAL AUTOMATION AND CONTROL LABORATORY 2 Credit Hours**

Laboratory utilizing programmable logic controllers, variable frequency drive motor control, human machine interfaces and industrial networking.

**Prerequisite:** ENGR 21020 (and ENGR 21022) or ENGR 35500 (and ENGR 35501).

**Corequisite:** ENGR 42620.

**Schedule Type:** Laboratory

**Contact Hours:** 4 lab

**Grade Mode:** Standard Letter

**ENGR 42710 ADDITIVE MANUFACTURING 2 Credit Hours**

An introduction to additive manufacturing (AM) technologies, designing for AM, post processing, AM applications and the future of additive manufacturing in engineering.

**Prerequisite:** ENGR 13585; and junior standing.

**Corequisite:** ENGR 42711.

**Schedule Type:** Lecture

**Contact Hours:** 2 lecture

**Grade Mode:** Standard Letter

**ENGR 42711 ADDITIVE MANUFACTURING LABORATORY 1 Credit Hour**

An introduction to additive manufacturing (AM) technologies, designing for AM, post processing, AM applications and the future of additive manufacturing in engineering.

**Prerequisite:** ENGR 13585; and junior standing.

**Corequisite:** ENGR 42710.

**Schedule Type:** Laboratory

**Contact Hours:** 2 lab

**Grade Mode:** Standard Letter

**ENGR 43026 MICROPROCESSOR SYSTEMS 4 Credit Hours**

(Slashed with ENGR 53026) Introduction to the architecture, operation and applications of an advanced microprocessor, focusing on assembly language programming and interfacing of standard programmable peripherals.

**Prerequisite:** ENGR 33222 and ENGR 46330.

**Schedule Type:** Laboratory, Lecture, Combined Lecture and Lab

**Contact Hours:** 3 lecture, 2 lab

**Grade Mode:** Standard Letter

**ENGR 43030 MECHATRONICS 3 Credit Hours**

(Slashed with ENGR 53030 and ENGR 73030) Application of automation concepts in motion control, electrical circuits, fundamental mechanics, control systems and programming, including modeling, interfacing and signal conditioning.

**Prerequisite:** ENGR 26220 and ENGR 26222; and PHY 13002 or PHY 23102.

**Pre/corequisite:** ENGR 33031 and ENGR 33041.

**Schedule Type:** Laboratory, Lecture, Combined Lecture and Lab

**Contact Hours:** 2 lecture, 2 lab

**Grade Mode:** Standard Letter

**ENGR 43050 INVENTIVE PROBLEM SOLVING 3 Credit Hours**

Theory of Inventive Problem Solving, TRIZ, is a collection of powerful problem-solving tools for a broad range of inventive problems. Capstone web-based course for students finishing their bachelor's degree. Assists students in utilizing material learned in earlier courses to solve many real world problems in multiple disciplines.

**Prerequisite:** Junior or senior standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 43080 INDUSTRIAL AND ENVIRONMENTAL SAFETY 3 Credit Hours**

Examines the occupational safety and health act and fundamentals of industrial safety programs.

**Prerequisite:** None.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 43099 MECHATRONICS CAPSTONE (ELR) (WIC) 3 Credit Hours**

Students work as members of integrated product teams to design and implement one or more mechatronics projects incorporating appropriate engineering standards and multiple design constraints. Final design report to include complete documentation of the design process, how constraints were met and all appropriate documentation of the final design (e.g. block and schematic diagrams, CAD models/drawings, a bill of materials, appropriate engineering calculations, discussion of the use of engineering standards).

**Prerequisite:** ENGR 43030.

**Schedule Type:** Project or Capstone

**Contact Hours:** 3 other

**Grade Mode:** Standard Letter

**Attributes:** Experiential Learning Requirement, Writing Intensive Course

**ENGR 43220 ELECTRICAL MACHINERY 3 Credit Hours**

Principles of operation and application of motors, generators, transformers and other magnetic devices; electrical power generation, distribution and use.

**Prerequisite:** None.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 43550 COMPUTER-AIDED MANUFACTURING 3 Credit Hours**

(Slashed with ENGR 53550) The application of computers to the preparation of machine tool control programs.

**Prerequisite:** ENGR 13585 and ENGR 20002.

**Schedule Type:** Laboratory, Lecture, Combined Lecture and Lab

**Contact Hours:** 2 lecture, 2 lab

**Grade Mode:** Standard Letter

**ENGR 43580 COMPUTER-AIDED MACHINE DESIGN 3 Credit Hours**

Application of the principles of mechanics and strength of materials, with computer assistance to the design and selection of machine components under both static and dynamic loads.

**Prerequisite:** ENGR 13585 or (ENGR 13590 and ENGR 13591); and ENGR 33111 or ENGR 42111 or MERT 22007.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 43899 APPLIED ENGINEERING CAPSTONE (ELR) 3 Credit Hours**

As the capstone course in Applied Engineering and Mechanical Engineering Technology, students develop and participate in all aspects of a project involving the solution of a problem through application of technology. Students must pass the ATMAE Certified Technology Manager (CTM) exam.

**Prerequisite:** Applied Engineering major or Mechanical Engineering Technology major; and senior standing.

**Schedule Type:** Project or Capstone, Seminar

**Contact Hours:** 1 lecture, 2 other

**Grade Mode:** Standard Letter

**Attributes:** Experiential Learning Requirement



**ENGR 45099 CAPSTONE: FOUNDRY TOOLING AND PATTERN MAKING (ELR) 3 Credit Hours**

Capstone course for Applied Engineering Foundry Technology concentration. A project based lecture-lab focused on production of foundry tooling, testing, and quality approval.

**Prerequisite:** ENGR 41065 and ENGR 43550.

**Schedule Type:** Laboratory, Lecture, Combined Lecture and Lab, Project or Capstone

**Contact Hours:** 2 lecture, 2 lab

**Grade Mode:** Standard Letter

**Attributes:** Experiential Learning Requirement

**ENGR 45121 AEROSPACE PROPULSION FOR ENGINEERING 3 Credit Hours**

An in-depth study of gas turbine engines, rockets and hypersonic propulsion systems used in aerospace applications. Includes propulsion system design and operation, and the analysis of performance characteristics.

**Prerequisite:** (PHY 13001 and PHY 13021) or PHY 23101; and junior standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 45151 APPLIED FLIGHT DYNAMICS II 3 Credit Hours**

Aerodynamics, flight dynamics, and flight performance of high performance aircraft. Course includes supersonic aerodynamics, flight stability and handling, and an in-depth investigation and analysis of flight performance parameters including lift, drag, load factor, climb performance, and turn performance.

**Prerequisite:** AERN 45150.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter-IP

**ENGR 45600 AIRCRAFT PERFORMANCE AND STABILITY II 3 Credit Hours**

Second of a two-course sequence in aircraft performance and flight mechanics. Aircraft design introduction, linearized equations of motion, aircraft dynamics modes, approximations and control, aircraft root locus analysis, aircraft handling qualities.

**Prerequisite:** ENGR 35300; and ENGR 33041 with a minimum C grade.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 45799 AIRCRAFT DESIGN I (ELR) 3 Credit Hours**

(Slashed with ENGR 55799) First of a two-course series of aerospace design. Preliminary design or case study of an aerospace vehicle, including but not limited, to aircraft, rotorcraft and spacecraft.

Primary focus on introduction to design, decision-making in design and preliminary sizing of an aerospace vehicle to meet customer requirements. Final technical report and presentation.

**Prerequisite:** (AERN 45030 and AERN 45150 and ENGR 45121) or (ENGR 35300 and ENGR 35500 and ENGR 45121).

**Schedule Type:** Project or Capstone

**Contact Hours:** 3 other

**Grade Mode:** Standard Letter

**Attributes:** Experiential Learning Requirement

**ENGR 45899 AIRCRAFT DESIGN II (ELR) (WIC) 3 Credit Hours**

(Slashed with ENGR 55899) Second of a two-course series of aerospace design. Preliminary design or case study of an aerospace vehicle, including but not limited to aircraft, rotorcraft, and spacecraft. Primary focus on sub-system design (i.e., propulsion, structure, controls, etc.), and overall vehicle integration of these subsystems. Cost analysis and safety analysis. Final technical report and or model prototype.

**Prerequisite:** ENGR 45799.

**Schedule Type:** Project or Capstone

**Contact Hours:** 3 other

**Grade Mode:** Standard Letter

**Attributes:** Experiential Learning Requirement, Writing Intensive Course

**ENGR 45901 INTRODUCTION TO FINITE ELEMENT METHOD AND APPLICATIONS 3 Credit Hours**

(Slashed with ENGR 55901 and ENGR 75901) The objective of this course is to teach in a unified manner the fundamentals of the finite element method for the analysis of engineering problems arising in solids and structures. The course emphasizes the solution of real-life problems using the finite element method, and students get exposure to commercial finite element software (ANSYS or ABAQUS) and learn to critically evaluate finite element models. Examples are provided for solid, fluid and heat transfer applications. Finally, developing an understanding of the computational aspects of the finite element method and its application in realistic aerospace applications are the core goals of this course.

**Prerequisite:** ENGR 13585 or (ENGR 13586 and ENGR 13587); and MATH 32044 or MATH 32052; and senior standing.

**Schedule Type:** Laboratory, Lecture, Combined Lecture and Lab

**Contact Hours:** 2 lecture, 2 lab

**Grade Mode:** Standard Letter

**ENGR 46099 COMPUTER ENGINEERING TECHNOLOGY CAPSTONE (ELR) 3 Credit Hours**

The course provides students with an integrative experience, applying aspects of the student's required coursework in computer engineering technology. Students gain experience in developing requirements in engineering specifications for a practical problem in networking and/or telecom-related projects. This course addresses emerging issues, capabilities and challenges in the current field of study.

**Prerequisite:** (ENGR 46351 and ENGR 46352) or ENGR 47200; and senior standing.

**Schedule Type:** Laboratory, Lecture, Combined Lecture and Lab, Project or Capstone

**Contact Hours:** 2 lecture, 2 lab

**Grade Mode:** Standard Letter

**Attributes:** Experiential Learning Requirement

**ENGR 46305 NETWORK SECURITY 2 Credit Hours**

Introduction to network security with emphasis in identifying, analyzing and preventing various threats and attack patterns on computer networks. Students gain practical knowledge on network security protocols, firewalls, VPN, intrusion detection and prevention systems. Prepares students for industry certification.

**Prerequisite:** ENGR 26305 and ENGR 26306.

**Corequisite:** ENGR 46306.

**Schedule Type:** Lecture

**Contact Hours:** 2 lecture

**Grade Mode:** Standard Letter

**ENGR 46306 NETWORK SECURITY LABORATORY 1 Credit Hour**

Introduction to network security with emphasis in identifying, analyzing and preventing various threats and attack patterns on computer networks. Students gain practical knowledge on network security protocols, firewalls, VPN, intrusion detection and prevention systems. Prepares students for industry certification.

**Prerequisite:** ENGR 26305 and ENGR 26306.

**Corequisite:** ENGR 46305.

**Schedule Type:** Laboratory

**Contact Hours:** 2 lab

**Grade Mode:** Standard Letter

**ENGR 46312 WIRELESS NETWORK AND TELECOMMUNICATION SYSTEMS 3 Credit Hours**

(Slashed with ENGR 56312) Course builds upon existing wired networking skills and extends students' knowledge into the world of wireless networking. Students learn digital wireless fundamentals, wireless standards, how to implement a wireless network in an enterprise environment and how to troubleshoot wireless issues. Curriculum follows and prepares students for industry certification in wireless networking.

**Prerequisite:** ENGR 26305 and ENGR 26306.

**Pre/corequisite:** ENGR 36305 and ENGR 36306.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 46316 SERVER ADMINISTRATION AND CONFIGURATION I 3 Credit Hours**

This course emphasizes on configuring and administering server operating systems to solve engineering problems. Students are expected to learn MS server management, Active Directory, OUs and server roles by utilizing variety of on-based and cloud based solutions.

**Prerequisite:** None.

**Schedule Type:** Laboratory, Lecture, Combined Lecture and Lab

**Contact Hours:** 2 lecture, 2 lab

**Grade Mode:** Standard Letter

**ENGR 46317 SERVER ADMINISTRATION AND CONFIGURATION II 2 Credit Hours**

Server Administration and Configuration II Lecture provides an in-depth coverage of the 70-741 certification exam objectives and focuses on the skills you need to configure networking with Windows Server 2016 and AZURE. After you finish this course, you'll have an in-depth knowledge of Windows Server 2016 networking services, including TCP/IP, DNS, DHCP, IPAM, remote access and advanced networking solutions.

**Prerequisite:** ENGR 46316.

**Corequisite:** ENGR 46318.

**Schedule Type:** Lecture

**Contact Hours:** 2 lecture

**Grade Mode:** Standard Letter

**ENGR 46318 SERVER ADMINISTRATION AND CONFIG II - LABORATORY 1 Credit Hour**

Server Administration and Configuration II Lab provides the hands-on component of ENGR 46317. It provides an in-depth coverage of the 70-741 certification exam objectives and focuses on the skills you need to configure networking with Windows Server 2016 and AZURE. After finishing this course, you'll have an in-depth knowledge of Windows Server 2016 networking services, including TCP/IP, DNS, DHCP, IPAM, remote access and advanced networking solutions.

**Prerequisite:** ENGR 46316.

**Corequisite:** ENGR 46317.

**Schedule Type:** Laboratory

**Contact Hours:** 2 lab

**Grade Mode:** Standard Letter

**ENGR 46330 VISUAL BASIC PROGRAMMING IN ENGINEERING TECHNOLOGY 3 Credit Hours**

(Slashed with ENGR 56330) Course includes programming in a high-level object-oriented, event-driven visual programming language, Visual Basic 2010 Express, conditional statements, iterative statements, arrays, object oriented programming, classes, objects, methods, inheritance, exception handling, graphical user interfaces with Windows Forms.

**Prerequisite:** ENGR 10005.

**Schedule Type:** Laboratory, Lecture, Combined Lecture and Lab

**Contact Hours:** 4 other

**Grade Mode:** Standard Letter

**ENGR 46351 NETWORK MANAGEMENT AND DESIGN 2 Credit Hours**

Course covers the technical aspects of centrally managed and distributed wide area networks, with an emphasis on the techniques used to maintain and improve the performance of telecommunications and data networks. Students use software packages to monitor the real-time performance of a network and to diagnose various networking hardware and software problems. Topics include the five stacks of network management (fault management, configuration management, performance management, security management and accounting management). Examples of current specific network management products are reviewed.

**Prerequisite:** ENGR 36305 and ENGR 36306.

**Corequisite:** ENGR 46352.

**Schedule Type:** Lecture

**Contact Hours:** 2 lecture

**Grade Mode:** Standard Letter

**ENGR 46352 NETWORK MANAGEMENT AND DESIGN LABORATORY 1 Credit Hour**

Course covers the technical aspects of centrally managed and distributed wide area networks, with an emphasis on the techniques used to maintain and improve the performance of telecommunications and data networks. Students use software packages to monitor the real-time performance of a network and to diagnose various networking hardware and software problems. Topics include the five stacks of network management (fault management, configuration management, performance management, security management and accounting management). Examples of current specific network management products are reviewed.

**Prerequisite:** ENGR 36305 and ENGR 36306.

**Corequisite:** ENGR 46351.

**Schedule Type:** Laboratory

**Contact Hours:** 2 lab

**Grade Mode:** Standard Letter

**ENGR 47200 SYSTEMS ENGINEERING 3 Credit Hours**

(Slashed with ENGR 57200) Systems engineering as a method to solve problems. Introduction to the fundamental systems engineering principles, processes, and methodologies used to analyze, design, develop, and deploy complex, sustainable systems. Focuses on systems engineering as a logical, disciplined, systematic, and coherent approach to the design and development of a system, across the full life cycle of the system. Special emphasis is made on the concepts, methods, and activities used to analyze systems, to define and allocate requirements, to transform requirements into a system design, and to verify and validate the system.

**Prerequisite:** Junior standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 47210 SUSTAINABLE ENERGY I 3 Credit Hours**

(Slashed with ENGR 57210) A comprehensive overview of energy sources and energy systems, with an emphasis on renewable energy and the implementation and sustainability of various forms of energy. Examines the characteristics of conventional non-renewable energy systems, along with alternate, renewable energy sources and systems. Includes fundamental energy concepts and the conversion, delivery, distribution, and storage of energy. Explores the technological application of various sources of energy and compares their benefits and limitations. Also presents an overview of present U.S. and global energy needs and demands, and the sustainable energy technologies that may be used to meet future energy demands.

**Prerequisite:** None.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 47211 SUSTAINABLE ENERGY II 3 Credit Hours**

(Slashed with ENGR 57211) An in-depth study of the analysis, selection and implementation of various energy and power sources, with an emphasis on the use of renewable, sustainable energy systems. Focuses on determining energy needs, and on assessing and comparing energy systems with respect to efficiency, technical feasibility, available resources, cost and sustainability characteristics. Includes economics of energy systems, methods for determining costs, and cost-benefit analysis of various energy and power systems. Also includes the social, economic and environmental impact associated with the development, implementation and use of various forms of energy.

**Prerequisite:** ENGR 47210.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 48001 ORBITAL MECHANICS 3 Credit Hours**

(Slashed with ENGR 58001 and ENGR 78001) The course is an introduction to orbital and trajectory design. Topics include Newton's law of gravity; two-body motion; relative equations of motion; conic sections; orbits in three dimensions; orbital maneuvers; and interplanetary transfers.

**Prerequisite:** ENGR 25400; and MATH 32044 or MATH 32052; and senior standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 48002 SPACECRAFT ATTITUDE DYNAMICS, DETERMINATION AND CONTROL 3 Credit Hours**

(Slashed with ENGR 58002 and ENGR 78002) Spacecraft rigid body dynamics in terms of direction cosine matrix, Euler angles, principal rotation vector and quaternions. Attitude determination using TRIAD, quaternion and matrix solutions to Wahba's problem and an introduction to recursive estimation and Kalman Filter. Nonlinear stability and control technique (i.e., Lyapunov Theory) is introduced and applied to the attitude stabilization and control problem.

**Prerequisite:** ENGR 25400 and MATH 32052; and senior standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 48003 SPACECRAFT DESIGN 3 Credit Hours**

(Slashed with ENGR 58003 and ENGR 78003) Spacecraft mission design course with a focus on hands-on design experience. The first portion of the course is lecture-based. Topics include launch systems, space environment, spacecraft orbits and ground tracks, spacecraft design and sizing, budget designs, subsystem design and evaluation, cost and risk. The second portion is dedicated to student teamwork on the spacecraft design.

**Prerequisite:** None.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 48010 MACHINE VISION 3 Credit Hours**

(Slashed with ENGR 58010 and ENGR 78010) Course explores concepts and techniques for image/video processing and machine vision. Topics covered include image formation, image filtering, edge detection and segmentation, object recognition, object detection and tracking, 3D vision, etc.

**Prerequisite:** Senior standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 48099 ENGINEERING CAPSTONE I (ELR) 3 Credit Hours**

First of a two-course capstone sequence for engineering and engineering technology students. Students work as members of an integrated product team under a faculty advisor to develop a conceptual design/prototype of a complex system that accomplishes a set of functional requirements. These projects can take the form of state, regional or national design competitions; governmental-sponsored projects; or industry-sponsored projects.

**Prerequisite:** (AERN 45030 and AERN 45150) or ENGR 35300 or ENGR 47200.

**Schedule Type:** Project or Capstone

**Contact Hours:** 3 other

**Grade Mode:** Standard Letter

**Attributes:** Experiential Learning Requirement

**ENGR 48199 ENGINEERING CAPSTONE II (ELR) (WIC) 3 Credit Hours**

Second of a two-course capstone sequence for engineering and engineering technology students. Students work as members of an integrated product team under a faculty advisor to develop a conceptual design/prototype of a complex system that accomplishes a set of functional requirements. These projects can take the form of state, regional, or national design competitions, governmental-sponsored projects, or industry-sponsored projects.

**Prerequisite:** ENGR 48099.

**Schedule Type:** Project or Capstone

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter-IP

**Attributes:** Experiential Learning Requirement, Writing Intensive Course

**ENGR 52111 STRENGTH OF MATERIALS FOR ENGINEERS 3 Credit Hours**

(Slashed with ENGR 42111 and ENGR 72111) The mathematical study of how materials respond to external forces. Stress, strain, torsion; deformation of thin-walled pressure vessels, beams and columns; and an introduction to energy methods.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 52363 MATERIALS SELECTION IN DESIGN AND APPLICATIONS 3 Credit Hours**

(Slashed with ENGR 42363 and ENGR 72363) Description and analysis of procedures for selecting appropriate materials for a particular mechanical design. The affect of processing on material properties, introduction to materials science for users of materials. Extensive case studies of materials selection and materials and sustainability.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 52410 ENGINEERING OPTIMIZATION 3 Credit Hours**

(Slashed with ENGR 42410 and ENGR 72410) This course will cover the theoretical foundations and present methods associated with the engineering optimization field, including: problem statement formulation; sensitivity methods; decomposition methods; Multidisciplinary Design Optimization (MDO) formulations; unconstrained and constrained 1-D and n-D search methods; and an introduction to heuristic search methods. Engineering optimization in the context of design of complex engineering systems will be discussed as well, with an emphasis on emerging techniques in the field.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 53030 MECHATRONICS 3 Credit Hours**

(Slashed with ENGR 43030 and ENGR 73030) Application of automation concepts in motion control, electrical circuits, fundamental mechanics, control systems and programming, including modeling, interfacing and signal conditioning.

**Prerequisite:** Graduate standing.

**Schedule Type:** Laboratory, Lecture, Combined Lecture and Lab

**Contact Hours:** 2 lecture, 2 lab

**Grade Mode:** Standard Letter

**ENGR 53550 COMPUTER-AIDED MANUFACTURING 3 Credit Hours**

(Slashed with ENGR 43550) The application of computers to the preparation of machine tool control programs.

**Prerequisite:** Graduate standing.

**Schedule Type:** Laboratory, Lecture, Combined Lecture and Lab

**Contact Hours:** 2 lecture, 2 lab

**Grade Mode:** Standard Letter

**ENGR 55799 AIRCRAFT DESIGN I 3 Credit Hours**

(Slashed with ENGR 45799) First of a two-course series of aerospace design. Preliminary design or case study of an aerospace vehicle, including but not limited, to aircraft, rotorcraft and spacecraft.

Primary focus on introduction to design, decision-making in design and preliminary sizing of an aerospace vehicle to meet customer requirements. Final technical report and presentation.

**Prerequisite:** Graduate standing.

**Schedule Type:** Project or Capstone

**Contact Hours:** 3 other

**Grade Mode:** Standard Letter

**ENGR 55899 AIRCRAFT DESIGN II 3 Credit Hours**

(Slashed with ENGR 45899) Second of a two-course series of aerospace design. Preliminary design or case study of an aerospace vehicle, including but not limited to aircraft, rotorcraft and spacecraft. Primary focus on sub-system design (i.e., propulsion, structure, controls, etc.), and overall vehicle integration of these subsystems. Cost analysis and safety analysis. Final technical report and or model prototype.

**Prerequisite:** ENGR 55799; and graduate standing.

**Schedule Type:** Project or Capstone

**Contact Hours:** 3 other

**Grade Mode:** Standard Letter

**ENGR 55901 INTRODUCTION TO FINITE ELEMENT METHOD AND APPLICATIONS 3 Credit Hours**

(Slashed with ENGR 45901 and ENGR 75901) The objective of this course is to teach in a unified manner the fundamentals of the finite element method for the analysis of engineering problems arising in solids and structures. The course emphasizes the solution of real-life problems using the finite element method, and students get exposure to commercial finite element software (ANSYS or ABAQUS) and learn to critically evaluate finite element models. Examples are provided for solid, fluid and heat transfer applications. Finally, developing an understanding of the computational aspects of the finite element method and its application in realistic aerospace applications are the core goals of this course.

**Prerequisite:** Graduate standing.

**Schedule Type:** Laboratory, Lecture, Combined Lecture and Lab

**Contact Hours:** 2 lecture, 2 lab

**Grade Mode:** Standard Letter

**ENGR 56312 WIRELESS NETWORK AND TELECOMMUNICATION SYSTEMS 3 Credit Hours**

(Slashed with ENGR 46312) Course builds upon existing wired networking skills and extends students' knowledge into the world of wireless networking. Students learn digital wireless fundamentals, wireless standards, how to implement a wireless network in an enterprise environment and how to troubleshoot wireless issues. Curriculum follows and prepares students for industry certification in wireless networking.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 56330 VISUAL BASIC PROGRAMMING IN ENGINEERING TECHNOLOGY 3 Credit Hours**

(Slashed with ENGR 46330) Course includes programming in a high-level object-oriented, event-driven visual programming language, Visual Basic 2010 Express, conditional statements, iterative statements, arrays, object oriented programming, classes, objects, methods, inheritance, exception handling, graphical user interfaces with Windows Forms.

**Prerequisite:** Graduate standing.

**Schedule Type:** Laboratory, Lecture, Combined Lecture and Lab

**Contact Hours:** 2 lecture, 2 lab

**Grade Mode:** Standard Letter

**ENGR 57200 SYSTEMS ENGINEERING 3 Credit Hours**

(Slashed with ENGR 47200) Systems engineering as a method to solve problems. Introduction to the fundamental systems engineering principles, processes, and methodologies used to analyze, design, develop, and deploy complex, sustainable systems. Focuses on systems engineering as a logical, disciplined, systematic, and coherent approach to the design and the development of a system, across the full life cycle of the system. Special emphasis is made on the concepts, methods and activities used to analyze systems, to define and allocate requirements, to transform requirements into a system design, and to verify and validate the system.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 57210 SUSTAINABLE ENERGY I 3 Credit Hours**

(Slashed with ENGR 47210) A comprehensive overview of energy sources and energy systems, with an emphasis on renewable energy and the implementation and sustainability of various forms of energy. Examines the characteristics of conventional non-renewable energy systems, along with alternate, renewable energy sources and systems. Includes fundamental energy concepts and the conversion, delivery, distribution, and storage of energy. Explores the technological application of various sources of energy and compares their benefits and limitations. Also presents an overview of presents U.S. and global energy needs and demands, and the sustainable energy technologies that may be used to meet future energy demands.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 57211 SUSTAINABLE ENERGY II 3 Credit Hours**

(Slashed with ENGR 47211) An in-depth study of the analysis, selection and implementation of various energy and power sources, with an emphasis on the use of renewable, sustainable energy systems. Focuses on determining energy needs, and on assessing and comparing energy systems with respect to efficiency, technical feasibility, available resources, cost and sustainability characteristics. Includes economics of energy systems, methods for determining costs, and cost-benefit analysis of various energy and power systems. Also includes the social, economic, and environmental impact associated with the development, implementation, and use of various forms of energy.

**Prerequisite:** ENGR 57210; and graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 58001 ORBITAL MECHANICS 3 Credit Hours**

(Slashed with ENGR 48001 and ENGR 78001) The course is an introduction to orbital and trajectory design. Topics include Newton's law of gravity; two-body motion; relative equations of motion; conic sections; orbits in three dimensions; orbital maneuvers; and interplanetary transfers.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 58002 SPACECRAFT ATTITUDE DYNAMICS, DETERMINATION AND CONTROL 3 Credit Hours**

(Slashed with ENGR 48002 and ENGR 78002) Spacecraft rigid body dynamics in terms of direction cosine matrix, Euler angles, principal rotation vector and quaternions. Attitude determination using TRIAD, quaternion and matrix solutions to Wahba's problem and an introduction to recursive estimation and Kalman Filter. Nonlinear stability and control technique (i.e., Lyapunov Theory) is introduced and applied to the attitude stabilization and control problem.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 58003 SPACECRAFT DESIGN 3 Credit Hours**

(Slashed with ENGR 48003 and ENGR 78003) Spacecraft mission design course with a focus on hands-on design experience. The first portion of the course is lecture-based. Topics include launch systems, space environment, spacecraft orbits and ground tracks, spacecraft design and sizing, budget designs, subsystem design and evaluation, cost and risk. The second portion is dedicated to student teamwork on the spacecraft design.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 58004 OPTIMAL CONTROL THEORY 3 Credit Hours**

(Slashed with ENGR 78004) The course introduces students to the theory and numerical calculation of optimal space trajectories and related optimization problems in aerospace engineering. This course provides the essential technical components of space trajectory design and space trajectory optimization. Students develop basic engineering skills in formulating and solving open-ended problems and in writing a project report.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 58010 MACHINE VISION 3 Credit Hours**

(Slashed with ENGR 48010 and ENGR 78010) Course explores concepts and techniques for image/video processing and machine vision. Topics covered include image formation, image filtering, edge detection and segmentation, object recognition, object detection and tracking, 3D vision, etc.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 60000 PROJECT MANAGEMENT IN A TECHNOLOGICAL ENVIRONMENT 3 Credit Hours**

The planning, organizing, directing and controlling of company technology resources for relatively short term objectives. Students will also learn to make application of current projects.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 60003 SIX-SIGMA: TOOLS AND APPLICATIONS FOR TECHNOLOGY MANAGEMENT 2 Credit Hours**

Principles and concepts of six-sigma to improve organizational efficiency, effectiveness and productivity by improving quality, reducing waste, defects and failures.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 2 lecture

**Grade Mode:** Standard Letter

**ENGR 60020 QUALITY STANDARDS 3 Credit Hours**

This course introduces students to issues in quality standards, quality assurance and statistical inference in applied technology and process control. Topics include systems reliability, quality control, SPC, control charts, principles and methods of statistical analysis and prediction, and hypothesis testing.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 60030 QUANTITATIVE METHODS I 2 Credit Hours**

Descriptive and inferential statistics used in technology and engineering. Emphasis is on the methods of analysis and the interpretation of data associated with research and development in technological and engineering environments. Course topics include representation of data, descriptive statistics, probability, and probability distributions. No previous familiarity with probability or statistics is assumed. The ability to utilize basic algebra is required.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 2 lecture

**Grade Mode:** Standard Letter

**ENGR 60040 QUANTITATIVE METHODS II 2 Credit Hours**

Descriptive and inferential statistics used in technology and engineering. Emphasis is on the methods of analysis and the interpretation of data associated with research and development in technological and engineering environments. Course topics include inferential statistics, statistical design, and the analysis of experiments. The ability to utilize basic algebra is required.

**Prerequisite:** Graduate standing.

**Pre/corequisite:** ENGR 60030.

**Schedule Type:** Lecture

**Contact Hours:** 2 lecture

**Grade Mode:** Standard Letter

**ENGR 60078 RESEARCH METHODS IN TECHNOLOGY 2 Credit Hours**

Research techniques for the technologist. Methods for designing, conducting, analyzing and interpreting results of technological research. Course allows students to become informed consumers of all forms of research used in different fields. Students identify various research approaches and the strengths and limitations associated with different approaches. Focus is on the context of educational research; philosophy underlying research; the scientific method; the relationship of theory to research; research strategies; experimental design; non-experimental design; sampling; hypotheses; and other pertinent aspects of research.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 2 lecture

**Grade Mode:** Standard Letter

**ENGR 60092 INDUSTRIAL PRACTICE 1-4 Credit Hours**

(Repeatable for credit) Practical experience in industry of a cooperative work-study nature.

**Prerequisite:** Graduate standing; and special approval.

**Schedule Type:** Practical Experience

**Contact Hours:** 3-12 other

**Grade Mode:** Standard Letter

**ENGR 61091 GRADUATE SEMINAR 1 Credit Hour**

(Repeatable for credit) Discussions of selected technical topics related to engineering research.

**Prerequisite:** Graduate standing.

**Schedule Type:** Seminar

**Contact Hours:** 1 other

**Grade Mode:** Standard Letter

**ENGR 61095 SPECIAL TOPICS IN ENGINEERING 1-3 Credit Hours**

(Repeatable for credit) (Slashed with ENGR 81095) Study of significant and current issues in various engineering topics not covered in regular courses. Offered when opportunities and resources permit; the topic is announced when the course is scheduled.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 1-3 lecture

**Grade Mode:** Standard Letter

**ENGR 61096 INDIVIDUAL INVESTIGATION IN ENGINEERING 1-3 Credit Hours**

(Repeatable for credit) (Slashed with ENGR 81096) Individual investigation for a topic in the field of engineering.

**Prerequisite:** Graduate standing.

**Schedule Type:** Individual Investigation

**Contact Hours:** 3-9 other

**Grade Mode:** Standard Letter

**ENGR 61099 ENGINEERING TECHNOLOGY CAPSTONE 2-6 Credit Hours**

(Repeatable for credit) Students complete either a comprehensive project at a workplace through employment or internship or a comprehensive research paper from an investigation. Student's goal is to demonstrate competence in their graduate area of study. Possibilities include empirical research, case studies, theoretical or applied projects or projects identified for a specific client. Students are evaluated on the use of knowledge and skills gained from other courses taken in the program.

**Prerequisite:** Graduate standing; and special approval.

**Schedule Type:** Project or Capstone

**Contact Hours:** 2-6 other

**Grade Mode:** Standard Letter

**ENGR 62610 INDUSTRIAL ROBOTICS AND VISION SYSTEMS 1 Credit Hour**

(Slashed with ENGR 72610) Students learn how to program a FANUC industrial robot using the teach pendant. They also learn how to set up and use an industrial robot vision system. Students who successfully complete this course and the corequisite lab will receive both FANUC Robotics Handling Tool Operation and Programming and FANUC V-iRVison Operation and Programming - 2D certificates of completion.

**Prerequisite:** Graduate standing.

**Corequisite:** ENGR 62611.

**Schedule Type:** Lecture

**Contact Hours:** 1 lecture

**Grade Mode:** Standard Letter

**ENGR 62611 INDUSTRIAL ROBOTICS AND VISION SYSTEMS LABORATORY 2 Credit Hours**

(Slashed with ENGR 72611) Students learn how to program a FANUC industrial robot using the teach pendant. They also learn how to set up and use an industrial robot vision system. Students who successfully complete this course and the corequisite lecture will receive both FANUC Robotics Handling Tool Operation and Programming and FANUC V-iRVison Operation and Programming - 2D certificates of completion.

**Prerequisite:** Graduate standing.

**Corequisite:** ENGR 62610.

**Schedule Type:** Laboratory

**Contact Hours:** 4 lab

**Grade Mode:** Standard Letter

**ENGR 62620 INDUSTRIAL AUTOMATION AND CONTROL 1 Credit Hour**

(Slashed with ENGR 72620) Course covers programmable logic controllers, variable frequency drive motor control, human machine interfaces and industrial networking.

**Prerequisite:** Graduate standing.

**Corequisite:** ENGR 62621.

**Schedule Type:** Lecture

**Contact Hours:** 1 lecture

**Grade Mode:** Standard Letter

**ENGR 62621 INDUSTRIAL AUTOMATION AND CONTROL LABORATORY 2 Credit Hours**

(Slashed with ENGR 72621) Laboratory utilizing programmable logic controllers, variable frequency drive motor control, human machine interfaces and industrial networking.

**Prerequisite:** Graduate standing.

**Corequisite:** ENGR 62620.

**Schedule Type:** Laboratory

**Contact Hours:** 4 lab

**Grade Mode:** Standard Letter

**ENGR 62710 ADDITIVE MANUFACTURING 2 Credit Hours**

(Slashed with ENGR 72710) An introduction to additive manufacturing (AM) technologies, designing for AM, post processing, AM applications and the future of additive manufacturing in engineering.

**Prerequisite:** Graduate standing.

**Corequisite:** ENGR 62711.

**Schedule Type:** Lecture

**Contact Hours:** 2 lecture

**Grade Mode:** Standard Letter

**ENGR 62711 ADDITIVE MANUFACTURING LABORATORY 1 Credit Hour**

(Slashed with ENGR 72711) An introduction to additive manufacturing (AM) technologies, designing for AM, post processing, AM applications and the future of additive manufacturing in engineering.

**Prerequisite:** Graduate standing.

**Corequisite:** ENGR 62710.

**Schedule Type:** Laboratory

**Contact Hours:** 2 lab

**Grade Mode:** Standard Letter

**ENGR 63010 INFORMATION TECHNOLOGY FUNDAMENTALS 3 Credit Hours**

Introduction to the hardware, architecture and operation of the personal computer and associated devices. Topics include personal computer architecture and operation fundamentals, basic hardware, data busses and ports, hardware component packaging, auxiliary hardware components, and computer assembly, basic hardware installation, configuration and troubleshooting.

**Prerequisite:** Graduate standing.

**Schedule Type:** Laboratory, Lecture, Combined Lecture and Lab

**Contact Hours:** 2 lecture, 2 lab

**Grade Mode:** Standard Letter

**ENGR 63031 PROGRAMMABLE LOGIC CONTROLLERS 3 Credit Hours**

Programmable logic controllers (PLCS) covering hardware, ladder logic programming, networking and communications. Programming timers, counters and sequencers and an introduction to human machine interfaces (HMIS). An understanding of basic electricity and computer technology is required.

**Prerequisite:** Graduate standing.

**Schedule Type:** Laboratory, Lecture, Combined Lecture and Lab

**Contact Hours:** 2 lecture, 2 lab

**Grade Mode:** Standard Letter

**ENGR 63041 MOTORS AND CONTROLLERS 3 Credit Hours**

Theory and application of AC and DC motors, motor control, and machine operations in mechatronic systems. Includes introduction to basic control system terms and devices, input and output transducers, signal conditioning, open loop and closed loop control, stability and performance.

**Prerequisite:** Graduate standing.

**Schedule Type:** Laboratory, Lecture, Combined Lecture and Lab

**Contact Hours:** 2 lecture, 2 lab

**Grade Mode:** Standard Letter

**ENGR 63050 TRIZ: THEORY OF INVENTIVE PROBLEM-SOLVING 3 Credit Hours**

TRIZ is a collection of powerful problem-solving tools for a broad range of inventive problems. The theory originated in Russia by the study of more than two million patents. Students utilize material learned in earlier courses to solve real world problems in multiple disciplines.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 63070 COMPUTER HARDWARE DESIGN AND INTEGRATION 3 Credit Hours**

In-depth study of personal computer (PC) and computer networking hardware. Topics include PC design, basic and auxiliary PC hardware components, PC assembly, PC upgrade and optimization, and PC repair, diagnosis and troubleshooting. Additional topics include computer networking hardware, network architecture, network communication protocols, and network installation, configuration and maintenance. Includes laboratory.

**Prerequisite:** Graduate standing.

**Schedule Type:** Laboratory, Lecture, Combined Lecture and Lab

**Contact Hours:** 2 lecture, 2 lab

**Grade Mode:** Standard Letter

**ENGR 63100 COMPUTER-AIDED DESIGN 3 Credit Hours**

Study of modern industrial practice using computers in advanced graphics, design and analysis including geometric dimensioning and tolerancing, parametric design, solid modeling and finite element analysis. Two hours lecture and two hours lab.

**Prerequisite:** Graduate standing.

**Schedule Type:** Laboratory, Lecture, Combined Lecture and Lab

**Contact Hours:** 1 lecture, 4 lab

**Grade Mode:** Standard Letter

**ENGR 64010 CONNECTIVITY AND INTEROPERABILITY IN INDUSTRY 3 Credit Hours**

This course focuses on integrating and administering multiple systems in an industrial environment.

**Prerequisite:** Graduate standing.

**Schedule Type:** Laboratory, Lecture, Combined Lecture and Lab

**Contact Hours:** 2 lecture, 2 lab

**Grade Mode:** Standard Letter

**ENGR 64312 ADVANCED WIRELESS TELECOMMUNICATION SYSTEM AND NETWORK TECHNOLOGIES 3 Credit Hours**

Describes technologies associated with wireless and telecommunications systems. Topics covered include public switch telephone network infrastructures, intelligent networks, wireless technologies in manufacturing enterprises, 3GPP standards, ITU standards.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 65098 RESEARCH 1-6 Credit Hours**

(Repeatable for credit) Varied topics according to student interest and faculty approval. The work is designed to conduct research on a topic, and it will result in a paper or other appropriate product.

**Prerequisite:** Graduate standing; and special approval.

**Schedule Type:** Research

**Contact Hours:** 3-18 other

**Grade Mode:** Satisfactory/Unsatisfactory

**ENGR 65199 THESIS I 2-6 Credit Hours**

(Repeatable for credit) Thesis students must register for a total of 6 hours, 2 to 6 hours in a single semester distributed over several semesters if desired.

**Prerequisite:** Graduate standing; and special approval.

**Schedule Type:** Masters Thesis

**Contact Hours:** 6-18 other

**Grade Mode:** Satisfactory/Unsatisfactory

**ENGR 65299 THESIS II 2 Credit Hours**

Thesis students must continue registration each semester until all degree requirements are met.

**Prerequisite:** Graduate standing.

**Schedule Type:** Masters Thesis

**Contact Hours:** 2 other

**Grade Mode:** Satisfactory/Unsatisfactory

**ENGR 65500 QUALITY SYSTEMS AND INDUSTRIAL PRODUCTIVITY 3 Credit Hours**

Tools and techniques for increasing industrial productivity through total quality management. Productivity improvement techniques involving human, technology, material, product and processes, utilizing value engineering, analytical models and scientific management tools in high-technology environment.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 65550 DESIGN AND ANALYSIS OF EXPERIMENTS IN TECHNOLOGY 3 Credit Hours**

Introduces planning and conducting experiments, as well as analyzing the resulting data using statistical techniques to obtain valid and objective conclusions. Also focuses on experiments performed in areas such as product design, manufacturing process development and process improvement.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 65700 APPLIED RELIABILITY ENGINEERING 3 Credit Hours**

Introduction to reliability engineering for engineering-technology management professionals. Course includes design for reliability, failure mode and failure effect analysis, reliability testing and measurement, statistical and mathematical modeling, assessment and forecasting.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 65800 BURN-IN AND STRESS-TESTING FOR RELIABILITY 3 Credit Hours**

Comprehensive course on reliability testing to analyze and establish reliability standards for components, products and systems. Specific emphasis on burn-in and stress testing procedures to perform effective reliability statistical calculations will be the major focus of the course.

**Prerequisite:** Graduate standing.

**Schedule Type:** Laboratory, Lecture, Combined Lecture and Lab

**Contact Hours:** 2 lecture, 2 lab

**Grade Mode:** Standard Letter

**ENGR 66380 ADVANCED NETWORKING 3 Credit Hours**

Provides students with experience in advanced computer networking techniques, including network architectures, network security, network virtualization and storage area networks.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter



**ENGR 67010 ETHICS, TECHNOLOGY AND THE ENVIRONMENT 3 Credit Hours**

Explores the fundamental issues of the interconnections between human beings and the environment, with an emphasis on the ethics and the importance of the sustainability. Takes an in-depth look at basic environmental concepts, ethics and values, as they relate to a wide range of practical subject matters, including technology, from global and national perspectives. Provides an in-depth look at sustainable systems and the ethical issues associated with sustainability as it relates to technology by focusing on common and future impacts as they apply to ethics, values and justice.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 67300 MEDICAL ROBOTICS 3 Credit Hours**

(Slashed with ENGR 77300) Introduction to the current development of medical robot, study the design and control of medical robot. Main focus of course is surgical robots and walking assistant robots.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 67400 ROBOTICS: KINEMATICS AND DESIGN 3 Credit Hours**

(Slashed with ENGR 77400) Course covers techniques to physically design, model, analyze and control a robotic system, especially robotic arms with serial structures. Provides students with a basic understanding of physics and mathematics of robotic kinematics and design. Students develop skills for force analysis, practice robotic programming and understand principles of robotic operation, sensing and path planning.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 68005 LINEAR SYSTEM ANALYSIS AND CONTROL 3 Credit Hours**

(Slashed with ENGR 78005) This course covers the analysis and synthesis of linear dynamical systems. Fundamental concepts including canonical representations, the state transition matrix and the properties of controllability and observability are discussed. The existence and synthesis of stabilizing feedback control laws using pole placement and linear-quadratic optimal control are discussed.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 68006 NONLINEAR SYSTEMS AND CONTROL 3 Credit Hours**

(Slashed with ENGR 78006) Overview of stability concepts and examination of various methods for assessing stability such as linearization and Lyapunov methods. Introduction to various design methods based on linearization, sliding modes, adaptive control and feedback linearization.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 68007 DIGITAL CONTROL SYSTEMS 3 Credit Hours**

(Slashed with ENGR 78007) This course covers design and analysis of sampled data and digital control systems. Fundamental concepts include introduction to digital control and discrete transform (z-transform), discrete and hybrid signal flow graphs (SFGs), solution of discrete-time state space models, time-response and characteristic equations, stability analysis for discrete time systems, root locus, Bode plot and Nyquist method for sampled data systems, pole placement and state estimation for discrete time systems.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 68008 INTRODUCTION TO ROBUST CONTROL 3 Credit Hours**

(Slashed with ENGR 78008) Course covers the fundamentals of robust control theory, with emphasis on stability and performance analysis in the time and frequency domains and design tools for robust performance and robust stability. Course examines how a controller can be designed taking into account uncertainties in the model of the plant. Some current research topics such as application of robust identification and control techniques to active vision systems also are addressed.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 68101 AUTONOMOUS UNMANNED AERIAL SYSTEMS 3 Credit Hours**

(Slashed with ENGR 78101) This course provides an advanced-level understanding of unmanned aerial vehicles in physical system design; payload; and stealth design, navigation and deployment regulations. This course introduces students to state-of-the-art artificial intelligence methods for UAS deployments in different urban, forest and water surface scenarios.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 68102 INTELLIGENT SENSING AND PLANNING OF UNMANNED AERIAL SYSTEMS 3 Credit Hours**

(Slashed with ENGR 78102) This course focuses on real world environment understanding for the UAV systems. This course introduces students to state-of-the-art artificial intelligence methods for planning UAV missions in the real world.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 71095 SPECIAL TOPICS IN ENGINEERING 1-3 Credit Hours**

(Repeatable for credit) Study of significant and current issues in various engineering topics not covered in regular courses. Offered when opportunities and resources permit; the topic is announced when the course is scheduled.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Lecture

**Contact Hours:** 1-3 lecture

**Grade Mode:** Standard Letter

**ENGR 72111 STRENGTH OF MATERIALS FOR ENGINEERS 3 Credit Hours**

(Slashed with ENGR 42111 and ENGR 52111) The mathematical study of how materials respond to external forces. Stress, strain, torsion; deformation of thin-walled pressure vessels, beams and columns; and an introduction to energy methods.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 72363 MATERIALS SELECTION IN DESIGN AND APPLICATIONS 3 Credit Hours**

(Slashed with ENGR 42363 and ENGR 52363) Description and analysis of procedures for selecting appropriate materials for a particular mechanical design. The affect of processing on material properties, introduction to materials science for users of materials. Extensive case studies of materials selection and materials and sustainability.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 72410 ENGINEERING OPTIMIZATION 3 Credit Hours**

(Slashed with ENGR 42410 and ENGR 52410) This course will cover the theoretical foundations and present methods associated with the engineering optimization field, including: problem statement formulation; sensitivity methods; decomposition methods; Multidisciplinary Design Optimization (MDO) formulations; unconstrained and constrained 1-D and n-D search methods; and an introduction to heuristic search methods. Engineering optimization in the context of design of complex engineering systems will be discussed as well, with an emphasis on emerging techniques in the field.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 72610 INDUSTRIAL ROBOTICS AND VISION SYSTEMS 1 Credit Hour**

(Slashed with ENGR 62610) Students learn how to program a FANUC industrial robot using the teach pendant. They also learn how to set up and use an industrial robot vision system. Students who successfully complete this course and the corequisite lab will receive both FANUC Robotics Handling Tool Operation and Programming and FANUC V-iRVison Operation and Programming - 2D certificates of completion.

**Prerequisite:** Doctoral standing.

**Corequisite:** ENGR 72611.

**Schedule Type:** Lecture

**Contact Hours:** 1 lecture

**Grade Mode:** Standard Letter

**ENGR 72611 INDUSTRIAL ROBOTICS AND VISION SYSTEMS LABORATORY 2 Credit Hours**

(Slashed with ENGR 62611) Students learn how to program a FANUC industrial robot using the teach pendant. They also learn how to set up and use an industrial robot vision system. Students who successfully complete this course and the corequisite lecture will receive both FANUC Robotics Handling Tool Operation and Programming and FANUC V-iRVison Operation and Programming - 2D certificates of completion.

**Prerequisite:** Doctoral standing.

**Corequisite:** ENGR 72610.

**Schedule Type:** Laboratory

**Contact Hours:** 4 lab

**Grade Mode:** Standard Letter

**ENGR 72620 INDUSTRIAL AUTOMATION AND CONTROL 1 Credit Hour**

(Slashed with ENGR 62620) Course covers programmable logic controllers, variable frequency drive motor control, human machine interfaces and industrial networking.

**Prerequisite:** Doctoral standing.

**Corequisite:** ENGR 72621.

**Schedule Type:** Lecture

**Contact Hours:** 1 lecture

**Grade Mode:** Standard Letter

**ENGR 72621 INDUSTRIAL AUTOMATION AND CONTROL LABORATORY 2 Credit Hours**

(Slashed with ENGR 62621) Laboratory utilizing programmable logic controllers, variable frequency drive motor control, human machine interfaces and industrial networking.

**Prerequisite:** Doctoral standing.

**Corequisite:** ENGR 72620.

**Schedule Type:** Laboratory

**Contact Hours:** 4 lab

**Grade Mode:** Standard Letter

**ENGR 72710 ADDITIVE MANUFACTURING 2 Credit Hours**

(Slashed with ENGR 62710) An introduction to additive manufacturing (AM) technologies, designing for AM, post processing, AM applications and the future of additive manufacturing in engineering.

**Prerequisite:** Doctoral standing.

**Corequisite:** ENGR 72711.

**Schedule Type:** Lecture

**Contact Hours:** 2 lecture

**Grade Mode:** Standard Letter

**ENGR 72711 ADDITIVE MANUFACTURING LABORATORY 1 Credit Hour**

(Slashed with ENGR 62711) An introduction to additive manufacturing (AM) technologies, designing for AM, post processing, AM applications and the future of additive manufacturing in engineering.

**Prerequisite:** Doctoral standing.

**Corequisite:** ENGR 72710.

**Schedule Type:** Laboratory

**Contact Hours:** 2 lab

**Grade Mode:** Standard Letter

**ENGR 73030 MECHATRONICS 3 Credit Hours**

(Slashed with ENGR 43030 and ENGR 53030) Application of automation concepts in motion control, electrical circuits, fundamental mechanics, control systems and programming, including modeling, interfacing and signal conditioning.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Laboratory, Lecture, Combined Lecture and Lab

**Contact Hours:** 2 lecture, 2 lab

**Grade Mode:** Standard Letter

**ENGR 75901 INTRODUCTION TO FINITE ELEMENT METHOD AND APPLICATIONS 3 Credit Hours**

(Slashed with ENGR 45901 and ENGR 55901) The objective of this course is to teach in a unified manner the fundamentals of the finite element method for the analysis of engineering problems arising in solids and structures. The course emphasizes the solution of real-life problems using the finite element method, and students get exposure to commercial finite element software (ANSYS or ABAQUS) and learn to critically evaluate finite element models. Examples are provided for solid, fluid and heat transfer applications. Finally, developing an understanding of the computational aspects of the finite element method and its application in realistic aerospace applications are the core goals of this course.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Laboratory, Lecture, Combined Lecture and Lab

**Contact Hours:** 2 lecture, 2 lab

**Grade Mode:** Standard Letter

**ENGR 77300 MEDICAL ROBOTICS 3 Credit Hours**

(Slashed with ENGR 67300) Introduction to the current development of medical robot, study the design and control of medical robot. Main focus of course is surgical robots and walking assistant robots.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 77400 ROBOTICS: KINEMATICS AND DESIGN 3 Credit Hours**

(Slashed with ENGR 67400) Course covers techniques to physically design, model, analyze and control a robotic system, especially robotic arms with serial structures. Provides students with a basic understanding of physics and mathematics of robotic kinematics and design. Students develop skills for force analysis, practice robotic programming and understand principles of robotic operation, sensing and path planning.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 78001 ORBITAL MECHANICS 3 Credit Hours**

(Slashed with ENGR 48001 and ENGR 58001) The course is an introduction to orbital and trajectory design. Topics include Newton's law of gravity; two-body motion; relative equations of motion; conic sections; orbits in three dimensions; orbital maneuvers; and interplanetary transfers.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 78002 SPACECRAFT ATTITUDE DYNAMICS, DETERMINATION AND CONTROL 3 Credit Hours**

(Slashed with ENGR 48002 and ENGR 58002) Spacecraft rigid body dynamics in terms of direction cosine matrix, Euler angles, principal rotation vector and quaternions. Attitude determination using TRIAD, quaternion and matrix solutions to Wahba's problem and an introduction to recursive estimation and Kalman Filter. Nonlinear stability and control technique (i.e., Lyapunov Theory) is introduced and applied to the attitude stabilization and control problem.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 78003 SPACECRAFT DESIGN 3 Credit Hours**

(Slashed with ENGR 48003 and ENGR 58003) Spacecraft mission design course with a focus on hands-on design experience. The first portion of the course is lecture-based. Topics include launch systems, space environment, spacecraft orbits and ground tracks, spacecraft design and sizing, budget designs, subsystem design and evaluation, cost and risk. The second portion is dedicated to student teamwork on the spacecraft design.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 78004 OPTIMAL CONTROL THEORY 3 Credit Hours**

(Slashed with ENGR 58004) The course introduces students to the theory and numerical calculation of optimal space trajectories and related optimization problems in aerospace engineering. This course provides the essential technical components of space trajectory design and space trajectory optimization. Students develop basic engineering skills in formulating and solving open-ended problems and in writing a project report.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 78005 LINEAR SYSTEM ANALYSIS AND CONTROL 3 Credit Hours**

(Slashed with ENGR 68005) This course covers the analysis and synthesis of linear dynamical systems. Fundamental concepts including canonical representations, the state transition matrix and the properties of controllability and observability are discussed. The existence and synthesis of stabilizing feedback control laws using pole placement and linear-quadratic optimal control are discussed.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 78006 NONLINEAR SYSTEMS AND CONTROL 3 Credit Hours**

(Slashed with ENGR 68006) Overview of stability concepts and examination of various methods for assessing stability such as linearization and Lyapunov methods. Introduction to various design methods based on linearization, sliding modes, adaptive control and feedback linearization.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 78007 DIGITAL CONTROL SYSTEMS 3 Credit Hours**

(Slashed with ENGR 68007) This course covers design and analysis of sampled data and digital control systems. Fundamental concepts include introduction to digital control and discrete transform (z-transform), discrete and hybrid signal flow graphs (SFGs), solution of discrete-time state space models, time-response and characteristic equations, stability analysis for discrete time systems, root locus, Bode plot and Nyquist method for sampled data systems, pole placement and state estimation for discrete time systems.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 78008 INTRODUCTION TO ROBUST CONTROL 3 Credit Hours**

(Slashed with ENGR 68008) Course covers the fundamentals of robust control theory, with emphasis on stability and performance analysis in the time and frequency domains and design tools for robust performance and robust stability. Course examines how a controller can be designed taking into account uncertainties in the model of the plant. Some current research topics such as application of robust identification and control techniques to active vision systems also are addressed.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 78010 MACHINE VISION 3 Credit Hours**

(Slashed with ENGR 48010 and ENGR 58010) Course explores concepts and techniques for image/video processing and machine vision. Topics covered include image formation, image filtering, edge detection and segmentation, object recognition, object detection and tracking, 3D vision, etc.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 78101 AUTONOMOUS UNMANNED AERIAL SYSTEMS 3 Credit Hours**

(Slashed with ENGR 68101) This course provides an advanced-level understanding of unmanned aerial vehicles in physical system design; payload; and stealth design, navigation and deployment regulations. This course introduces students to state-of-the-art artificial intelligence methods for UAS deployments in different urban, forest and water surface scenarios.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 78102 INTELLIGENT SENSING AND PLANNING OF UNMANNED AERIAL SYSTEMS 3 Credit Hours**

(Slashed with ENGR 68102) This course focuses on real world environment understanding for the UAV systems. This course introduces students to state-of-the-art artificial intelligence methods for planning UAV missions in the real world.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**ENGR 81091 GRADUATE SEMINAR 1 Credit Hour**

(Repeatable for credit) Discussions of selected technical topics related to aerospace engineering.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Seminar

**Contact Hours:** 1 other

**Grade Mode:** Standard Letter

**ENGR 81095 SPECIAL TOPICS IN ENGINEERING 1-3 Credit Hours**

(Slashed with ENGR 61095)(Repeatable for credit) Study of significant and current issues in various engineering topics not covered in regular courses. Offered when opportunities and resources permit; the topic is announced when the course is scheduled.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Lecture

**Contact Hours:** 1-3 lecture

**Grade Mode:** Standard Letter

**ENGR 81096 INDIVIDUAL INVESTIGATION IN ENGINEERING 1-3 Credit Hours**

(Slashed with ENGR 61096)(Repeatable for credit) Individual investigation for a topic in the field of engineering.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Individual Investigation

**Contact Hours:** 3-9 other

**Grade Mode:** Standard Letter

**ENGR 85098 RESEARCH 1-6 Credit Hours**

(Repeatable for credit) Varied topics according to student interest and faculty approval. The work is designed to conduct research on a topic, and it will result in a paper or other appropriate product.

**Prerequisite:** Doctoral standing; and special approval.

**Schedule Type:** Research

**Contact Hours:** 3-18 other

**Grade Mode:** Satisfactory/Unsatisfactory

**ENGR 85199 DISSERTATION I 15 Credit Hours**

(Repeatable for credit) Doctoral dissertation, for which registration in at least two semesters is required, first of which will be semester in which dissertation work is begun and continuing until the completion of 30 hours.

**Prerequisite:** Doctoral standing; and special approval.

**Schedule Type:** Dissertation

**Contact Hours:** 15 other

**Grade Mode:** Satisfactory/Unsatisfactory

**ENGR 85299 DISSERTATION II 15 Credit Hours**

(Repeatable for credit) Continuing registration required for doctoral students who have completed the initial 30 hours of dissertation and continuing until all degree requirements are met.

**Prerequisite:** Doctoral standing; and special approval.

**Schedule Type:** Dissertation

**Contact Hours:** 15 other

**Grade Mode:** Satisfactory/Unsatisfactory