School of Engineering

Dean: Jeffrey W. Holmes, MD, PhD
Associate Dean for Academic Affairs & Graduate Programs: Gregg M. Janowski, PhD
Associate Dean for Undergraduate Programs: Andrew Sullivan, MSCE, PE
Associate Dean for Research: Mark Banaszak Holl, PhD

The School of Engineering is comprised of four departments: Biomedical Engineering; Civil, Construction, and Environmental Engineering; Electrical and Computer Engineering; and Mechanical and Materials Engineering. The School offers seven programs leading to a master's degree and six programs leading to a doctoral degree. In addition, the Neuroengineering PhD program is jointly offered by the School of Engineering and the School of Medicine.

Graduate education at UAB's School of Engineering is about advancing your career, whether your goal is engineering practice, industrial research, further studies, or academia. The Master of Engineering (MEng) and Masters of Science in Engineering Management (MSEM) emphasize specialized skills in engineering management, information management, leadership, construction, structures, sustainable smart cities, and safety. Our research-based masters of science and doctoral programs bring students and faculty together with medical professionals, practicing engineers, business leaders, and scientists to push the envelope and discover new, innovative solutions for the challenges of our world.

ASEM-Adv Safety Engineering Courses

ASEM 601. ASEM Seminar. 0 Hours.
Seminar focusing on student research and guest presentations of various topics of interest to safety and risk management engineers and safety professionals.

ASEM 610. Introduction to System Safety - Prevention through Design. 3 Hours.
This course sets the foundation for the ASEM program by providing an overview of all major topic areas and an introduction to many of the tools and approaches to system safety, management systems, and human factors. Topics of inquiry include the processes of hazard analysis and risk assessment, error and error-provocative environments, drift, ISO 45001, systems thinking, prevention through design, and decision making. Course content is presented in a research-to-practice format where students apply course content to their own business environment and bring their organization into the classroom. Guest lecturers from diverse backgrounds will discuss their experiences in managing safety in the workplace. Participation in periodic live dialogues is required. The course must be taken during the first semester.

ASEM 611. Hazard Analysis and Waste Elimination. 3 Hours.
Hazards have the potential to cause harm to people, planet, and profits. Hazard analysis is a process that begins with the identification of a hazard and proceeds into an estimate of the severity of harm or damage that could result if the potential is realized and a hazard-related incident occurs (ASSE TR-Z790.001 – 2009). This course examines engineering techniques utilized to systematically and logically identify and analyze hazards in the workplace. These techniques include preliminary hazard list (PHL), preliminary hazard analysis (PHA), and Operating and Support Hazard Analysis (O&SHA). Students work in teams to use the PHA to retrospectively analyze a real-world disaster. Additionally, many hazard analysis processes ultimately end up assigning blame or finding human error as a cause of hazards and accidents. The 5 Principles of Human Performance will be introduced to help students understand how people are a vital part of the system. Students will apply these 5 principles to their team PHA project and to an Individual O&SHA project.
Prerequisites: ASEM 610 [Min Grade: B]

ASEM 612. Engineering Risk. 3 Hours.
Engineering risk is defined both quantitatively and qualitatively as an estimate of the probability that a hazard-related incident will occur and of the severity of harm or damage that could result. This course provides students with tools to assess and reduce safety risks in their own company. These tools include risk assessment matrices, probabilistic risk assessment (PRA) measures, including event tree analysis, fault tree analysis, and other prevention through design concepts. The role of a structured, formalized decision analysis process in preventing serious injuries and fatalities is also explored. Students engage in a risk mitigation decision analysis project, which is specific to their company and/or business sector. Guest lecturers from diverse industries discuss their experiences in assessing and managing risk. Live participation in a weekly 1.5 hour online forum is required.
Prerequisites: ASEM 611 [Min Grade: B]

ASEM 613. Human Performance and Engineering Design. 3 Hours.
Companies can miss important opportunities to eliminate waste if they rely primarily on training to prevent human error. This course explores the historical perspective on human error and serious injury. The course material will provide a solid understanding of the principles of occupational biomechanics and human tolerance to injury with focus on human anthropometry and mechanical work capacity. This course also includes studies of human reliability, static analysis of systems in equilibrium and mechanical systems, design and performance. Due to the quantity of back related injuries and related lost time in the workplace, back pain and injury is studied along with the effect of vibration on the human body. Real-world case studies provide for application of the engineering hierarchy of controls: hazard elimination, hazard substitution, engineering controls, warnings, administrative behavior controls, and personal protective equipment. The course also examines the design aspects of ergonomics, the biomechanical engineering basis of injury prevention, and the long-term economic consequences of seemingly minor injuries. In semester projects, students perform incident investigations using biomechanical and other data. After gathering and analyzing data to determine injury causation, they will identify and re-design error-provocative environments in their own workplaces. Guest lecturers from diverse backgrounds will discuss their experiences with human performance and/or biomechanics. Live participation in a weekly 1.5 hour online forum is required.
Prerequisites: ASEM 610 [Min Grade: B]

ASEM 614. Engineering Ethics and Acceptable Risk. 3 Hours.
This course explores the economic, social, and political consequences of safety risk and considers provocative real-world dilemmas: What is acceptable risk? Are the fundamental canons of engineering ethics and safety ethics contrary to the concept of acceptable risk? What is the worth of human life? Students will conduct critical reviews of corporate safety and ethics policies from their own company. Real-world case studies provide the framework for exercises and are used throughout course discussion boards, assignments, and dialogues. Participation in periodic live dialogue is required.
Prerequisites: ASEM 610 [Min Grade: B](Can be taken Concurrently)

ASEM 615. Leading through Climates of Change. 3 Hours.
All progressive companies are moving toward greater sustainability - protecting people, planet, and profits. To guide their companies through these changes and integrate safety into the priorities at the executive level, safety engineers and professionals must have strong leadership skills. This course explores engineering leadership best practices, including the eight steps of transformational leadership - creating a sense of urgency, creating a guiding coalition, developing a vision and strategies, communicating the vision, empowering broad-based action, generating short term wins, consolidating gains and anchoring the culture. This course also explores the concept of Resilience Engineering and helps students understand the impacts of socio-technical risks. Guest lecturers from diverse industries discuss their experiences in managing change in today's global business environment. Live participation in a weekly 1.5 hour online forum is required.
Prerequisites: ASEM 610 [Min Grade: B]

ASEM 616. Policy Issues in Prevention through Design. 3 Hours.
This course provides an overview of best practices in four major policy areas: (1) cost-benefit analysis; (2) corporate culture and the "HR Department"; (3) standards, codes, and regulations; and (4) strategic alliance development. Case studies are used to illuminate both the role of engineers and other safety professionals in shaping public policy on the local, national and international levels and the ethical challenges they encounter. The significance of an organization's corporate culture in developing and implementing advanced safety management plans is also explored. Students conduct "gap analyses" of their company's policies by comparing them to best practices and identifying unintended consequences of poor safety policy in their own business and industry sector. Students will engage in discussion board posts on contemporary policy issues and participate in exercises related to federal rulemaking. Guest lecturers from diverse backgrounds will discuss their experiences with policy issues. Live participation in a weekly 1.5 hour online forum is required.
Prerequisites: ASEM 610 [Min Grade: B]

ASEM 617. Crisis Leadership. 3 Hours.
Leadership requires more than the predication, control, and management of the vast network of influences that make up our work, especially in times of crisis. By its nature, a crisis is an unpredicted event that requires sensemaking and innovation to go beyond immediate recovery, to step forward into learning. We can only do this when we value, trust, and communicate with the people in our systems. This course will explore why complex adaptive systems are different and may be understood and influenced by leadership at all levels before, during, or after a crisis. Students will assess their own organizational culture through the artifacts, espoused values, and deep assumptions and learn to shape these through relationships, sensemaking, and divergent thinking. This course includes two-week long learning modules based on a combination of written discussion boards that emphasize academic rigor, small group dialogues, network mindmapping, and dynamic online Zoom classes with the professors.
Prerequisites: ASEM 610 [Min Grade: B]

ASEM 619. Capstone Project - Part 1. 3 Hours.
This course is designed to understand how to apply many of the ASEM topics and bring to bear the competencies acquired through the program. Part of this is developing an understanding of the complex nature of human contributions. Students will be challenged to correlate learnings from the ASEM Program that lead to the creation of safer work systems and in so doing develop a concept for their capstone project.
Prerequisites: ASEM 612 [Min Grade: B] and (ASEM 613 [Min Grade: B] or ASEM 614 [Min Grade: B] or ASEM 615 [Min Grade: B] or ASEM 616 [Min Grade: B] or ASEM 617 [Min Grade: B] or ASEM 628 [Min Grade: B](Can be taken Concurrently)

ASEM 620. Capstone Project - Part 2. 3 Hours.
Capstone Projects serve as a culminating academic and intellectual experience for students. They are an opportunity to create a multifaceted project representing what students have learned during the ASEM Program. Unique approaches to the application of theory and research are encouraged as students are tasked with developing a project that suites their needs, and interests, while simultaneously demonstrating key learnings explored in the ASEM program. Students will be challenged to develop a capstone project that demonstrates mastery of the theories, concepts, and skills learned during the ASEM program and detail how they have applied or will apply them to a real-world situation.
Prerequisites: ASEM 617 [Min Grade: B] and ASEM 619 [Min Grade: B]

ASEM 626. Learning-Based Response to Organizational Accidents and Incidents. 3 Hours.
Accident investigations are an inevitable part of most industries, yet most incident analysis is based on models that were developed many decades ago. Current research indicates that 80% of accidents are attributed to human error. Yet few tools or processes are designed to examine the context of human actions. Human interactions exist in complex systems, which are by nature unpredictable. When we look at human involvement, we find that actions are influenced by conditions extant in the system. The goal of this course is to discover the importance of dedicating time and resources to understanding why humans are integral to safety in complex systems. Students will learn both the theory and practical application of new techniques that expand the ability of organizations to learn from events. Students will explore the history of accident investigation, its influence on culture, the importance of context in the evaluation of human actions, the inclusion of complex narratives in reports, and how to present their findings to leadership and the field. Overall, students will come away with a more practical ability to help their organization learn from events. The course structure is focused on case study analysis, peer-to-peer learning and research. Questions are designed to challenge current understanding of the human contribution to accidents and why actions or decisions made sense to those involved at the time.
Prerequisites: ASEM 617 [Min Grade: B]

ASEM 627. Communication in Safety Systems. 3 Hours.
Communication plays a powerful role in creating safety in the work environment. Effective language increases communication and can lead to individual and organizational learning during safety training, real-time work, and post-mission analysis. However, the meaning of our language is not constant – it changes based on the experience of the worker, the context of the event, and the culture that surrounds the work environment. Language can become ineffective, or even damaging, when meanings differ or go unchallenged. This can occur when definitions are assumed, linguistic shortcuts are taken, or when language bias demands a singular interpretation. Engineers work with mechanical systems, which can be defined by a specific language: e.g. binary oppositions, like turning a switch 'on' or 'off'. However, engineers also work with other people and must take human factors into account, including effective communication. This is the case with safety specialists, who help create the system architecture and develop practical training for workers in risk and safety. These specialists may be expected to participate in accident investigations or incident reviews, which can be unintentionally biased by the language used, which lead away from learning opportunities.
Prerequisites: ASEM 617 [Min Grade: B]

ASEM 628. Electrical Systems Safety. 3 Hours.
There is a subset of occupational hazards characterized as low frequency, but with very high consequence (potential for catastrophic loss, fatality or permanent disabling injury). A mishap involving unintentional exposure or contact with electrical energy is one of the low frequency/high consequence exposures. We live in an electrical world, with electrical hazards embedded in nearly every aspect of daily living – at home, at work, in public places, and in recreational activities. This course explores hazards, risks and context of electrical mishaps coupled with a systems safety engineering approach to manage the risks. Course content is presented within the framework of real-world case studies from a variety of industry sectors, including, but not limited to, manufacturing, utilities, and health care and includes several guest lectures by leaders in the profession. Students apply course content to their own business environment. Live participation in a weekly 1.5 hour online forum is required.
Prerequisites: ASEM 610 [Min Grade: B]

ASEM 630. Machinery Safety Management System. 3 Hours.
Safeguarding technology and requirements has come a long way since the Industrial Revolution. Despite this progress, the lack of effective machine guarding and management has continuously been named one of OSHA's topmost-cited violations. Most businesses assume that the machine manufacturer and installer have met safety compliance requirements, but have they? Some site safety professionals use a standard general safety checklist to verify machine safety requirements but is this enough? The goal of this course is to equip the student with working knowledge of machine safety through understanding and applying key machine safety compliance standards, e.g. ANSI B11.0, ANSI B11.19, NFPA 79, and ISO 13849-1. This course will focus on and apply to power-driven machines used to produce or process material. Within the course, students will evaluate their current machine management systems to determine obstacles, best practices, and solutions to further develop their knowledge of machine technology and management. Students will conduct a machine task-based risk assessment, utilize the hierarchy of control to select risk reduction measures, and verify and test selected safeguards to mitigate risks to an acceptable level. To ensure that the machine safety management process is sustainable, students will utilize ANSI Z10 or ISO 45001 to develop a machine safety management system outline to be used at their site or within a company.
Prerequisites: ASEM 610 [Min Grade: B]

ASEM 636. Human Organizational Potential. 3 Hours.
Human Organization Potential (HOP) is one of the most popular and in demand safety programs worldwide yet relies almost exclusively on one-day dialogues to introduce workers and management to non-academic content. However, the origin of HOP has a strong academic foundation based on research and field trials. This course will examine the historical foundation and supporting academic research of HOP principles and practices. It will show the relevance of this approach to improving safety systems and creating work environments that optimize learning potential in organizations.
Prerequisites: ASEM 610 [Min Grade: C] and ASEM 617 [Min Grade: C]

ASEM 637. Applied Semiotics in Safety Systems. 3 Hours.
Semiotics is the study of how meaning is created through symbolic communication that is taken in through our senses. A sign can be anything (object, process, activity, conduct) that communicates meaning to another person, who then interprets and makes sense of the sign. The meaning may be intentionally constructed (e.g. advertisements, workplace safety signs) or unintentional (e.g. a cough and fever might be a sign of Covid). Semiotics includes the systems into which signs are organized and the social and cultural contexts where they gain relevance. This course will focus mostly on visual semiotics, as these are the ones most encountered in safety systems. The module topics will open the perception of students to the semiotics around them, help make sense of intentional and unintentional information, and empower them to communicate their knowledge to others. Course information will come from peer-reviewed academic resources which will then be practically applied by students to create positive changes in workplace semiotics.
Prerequisites: ASEM 610 [Min Grade: C] and ASEM 617 [Min Grade: C]

ASEM 640. Introduction to Model-Based Safety Assessments. 3 Hours.
This course provides students an introduction to model-based engineering and methods to assess holistic safety risks in their own company. These tools include requirements development, functional decomposition, design architecture, probabilistic risk assessment (PRA) measures, including, failure mode effects and criticality analysis (FMECA), fault tree analysis (FTA), and other safety engineering concepts. The role of a structured, formalized model-based engineering process, used to identify and mitigate hazards, is explored. Students engage in a rigorous model-based safety analysis project.
Prerequisites: ASEM 612 [Min Grade: B]

ASEM 650. AI for Workplace Safety Opportunities, Applications, and Ethical Considerations. 3 Hours.
This advanced course examines the rapidly evolving intersection of Artificial Intelligence (AI) and occupational safety, preparing safety professionals to navigate the transformative impact of AI technologies on workplace risk management. This course will provide an overview of the history of AI to include elements within AI (machine learning, deep learning, generative AI, and large language models (LLMs) etc. The course will provide examples and experiential opportunities for the students related to robotics, computer vision, virtual reality, automation, and deep learning data analysis for causation. The course will include interactive opportunities for each student to better understand how their collaboration and partnership with AI technical experts can amplify their impact on safety. And this course will teach safety professionals how to develop actual business cases to equip them with proven mechanisms to drive large scale change within their organizations using AI and other forms of advanced technology.
Prerequisites: ASEM 610 [Min Grade: C]

ASEM 651. Emerging Trends in Safety Engineering. 3 Hours.
This course explores emerging trends affecting environmental health and safety engineering functions across industries, including regulatory, societal, business, and technological developments. Participants will evaluate specific emerging trends, such as Environmental, Social, and Governance (ESG), Corporate Social Responsibility (CSR), and innovations in technology that they can expect to encounter within their organizations as well as the interactive relationships that EHS has with these trends. Lectures, group discussions, personalized feedback, and peer to peer engagement will be utilized to support learners in their development.
Prerequisites: ASEM 610 [Min Grade: C]

ASEM 652. Safety Management Systems. 3 Hours.
This course explores and supports the development of an ISO 45001 Management System throughout a participant’s organization. Working through the ISO 45001 Standard step by step, participants will come to not only understand the nuances and intricacies of the standard but also have practice taking actionable steps to develop, complete, and implement in their organization. Lectures, group discussions, personalized feedback, and peer to peer engagement will be utilized to support learners in their development.
Prerequisites: ASEM 610 [Min Grade: C]

ASEM 690. Special Topics in (Area). 1-3 Hour.
Special Topics.

ASEM 691. Individual Study in (Area). 1-6 Hour.
Individual study.

ASEM 695. ASEM Journal Club. 1-3 Hour.
This course will help the student conduct research in support of identifying a research topic, conducting research associated with that topic, and ultimately preparing a research proposal and literary review.
Prerequisites: ASEM 610 [Min Grade: C]

BME-Biomedical Engineering Courses

BME 520. Implant-Tissue Interactions. 3 Hours.
An overview of implant biocompatibility including tissue histology, histopathology of implant response and the regulatory process for medical devices.

BME 524. Current Topics in Stem Cell Engineering. 3 Hours.
This course is designed for students interested in the field of stem cells, regenerative medicine, and tissue engineering using stem cells and stem cell derived cells. The course will introduce the role of stem cells in tissue growth and development, the theory behind the design and in vitro construction of tissue and organ replacements, and the applications of biomedical engineering principles to the treatment of tissue-specific diseases. Students will have hands on experience on culturing and analyzing stem cells, stem cell differentiation, analysis of functional and physiological properties of differentiated cells, and fabricating basic engineered-tissues.

BME 535. Tissue Engineering. 3 Hours.
Principles underlying strategies for regenerative medicine such as stem cell based therapy, scaffold design, proteins or genes delivery, roles of extracellular matrix, cell-materials interactions, angiogenesis, tissue transplantation, mechanical stimulus and nanotechnology.

BME 543. Medical Image Processing. 3 Hours.
Fundamental topics of medical image processing to practical applications using conventional computer software.

BME 544. Machine Learning for Biomedical Engineering Applications. 3 Hours.
This course provides the introduction to the practical aspects of machine learning such that the students can apply some basic machine learning techniques in simple biomedical engineering problems. The course also provides the principle of machine learning ‘thinking process’ for the next machine learning – AI courses and more in-depth machine learning studies. By ‘thinking process’, at the beginning, it is better to view machine learning like human learning. Students who have experience with Data Mining may further understand the fundamental differences between Machine Learning and Data Mining, although these two fields share many concepts and techniques. Also, the student will learn fundamental theories in machine learning to be able to develop new machine learning techniques and research machine learning in biomedical engineering.

BME 550. Computational Neuroscience. 3 Hours.
This course examines the computational principles used by the nervous system. Topics include: biophysics of axon and synapse, sensory coding (with an emphasis on vision and audition), planning and decision-making, and synthesis of motor responses. There will be an emphasis on a systems approach throughout. Homework includes simulations.

BME 561. Bioelectric Phenomena. 3 Hours.
Quantitative methods in the electrophysiology of neural, cardiac and skeletal muscle systems.

BME 562. Cardiac Electrophysiology. 3 Hours.
Experimental and computational methods in cardiac electrophysiology, ionic currents, action potentials, electrical propagation, the electrocardiogram, electromechanical coupling, cardiac arrhythmias, effects of electric fields in cardiac tissue, defibrillation, and ablation.

BME 565. Mechanobiology. 3 Hours.
The overall course objective is to develop understanding of mechanobiological processes in cells as they relate to both development and disease pathways. The course will focus on cancer and vascular biology, however there is significant overlap of these pathways with developmental signaling pathways. Students will learn not only molecular biology techniques for characterizing mechanobiology and cell phenotype but also be able to describe biomechanical analysis protocols including micropipette aspiration, atomic force microscopy, traction force microscopy, and optical/magnetic tweezers. The course will include comprehensive literature reviews relevant to the subject area. Students will present formal presentations on articles discussing mechanobiology topics; students will prepare a written report in the style of a commentary article on a published journal article discussing a relevant mechanobiological project.

BME 571. Continuum Mechanics of Solids. 3 Hours.
Matrix and tensor mathematics, fundamentals of stress, momentum principles, Cauchy and Piola-Kirchoff stress tensors, static equilibrium, invariance, measures of strain, Lagrangian and Eulerian formulations, Green and Almansistrain, deformation gradient tensor, infinitesimal strain, constitutive equations, finite strain elasticity, strain energy methods, 2-D Elasticity, Airy Method, viscoelasticity, mechanical behavior of polymers.

BME 572. Industrial Bioprocessing and Biomanufacturing. 3 Hours.
This course will introduces students to the growing industries related to biomedical, biopharmaceutical and biotechnology. It is targeted to offer the students marketable skills to work in a vital area of economic growth and also convey some of the challenges and opportunities awaiting.

BME 590. Special Topic in Biomedical Engineering. 1-3 Hour.
Special Topic in Biomedical Engineering.

BME 591. Individual Study in Biomedical Engineering. 1-6 Hour.
Individual Study in Biomedical Engineering.

BME 601. Seminar in Biomedical Engineering. 1 Hour.
Current topics in biomedical engineering technology and applications.

BME 605. Insights to Innovations BME Journal Club. 1 Hour.
Insights to Innovations (i2i) BME Scholar’s Pulse is a Journal Club designed to facilitate critical analyses and discussion of current research in the field of biomedical engineering. Students will learn how to conduct literature searches, read and evaluate scientific articles, and present research findings effectively. Students will develop their presentation and discussion skills and gain a deeper understanding of the various subfields of biomedical engineering.

BME 617. Engineering Analysis. 3 Hours.
Advanced ordinary differential equations, transform techniques, scalar and vector field theory, partial differential equations (heat, wave, Laplace). Students who register for this course are expected to have successfully completed courses in calculus and ordinary differential equations.

BME 623. Skin and Bone Regeneration. 3 Hours.
Study of principles of healing, methods to enhance, and clinical applications.

BME 625. Immune-Engineering: Biomaterial Toolbox for Immune-Modulation. 3 Hours.
This course introduces immunology and engineering approaches to study and control immune response using biomaterials. The course is geared towards students/engineers without a deeply established background in immunology. Basic principles in immunology will be covered and contemporary research directions will be discussed based on articles from the primary literature. Biomaterials will be presented as a tool for modifying immune responses.

BME 634. Dynamical Biological Systems. 3 Hours.
This course considers the dynamics of biological systems at a variety of levels from the cell/molecular to the circuit and system levels. Biological systems are typically nonlinear and their behavior is not usually analytically solvable. Yet it is possible to use the tools of nonlinear dynamical systems theory to approach understanding. In addition, it is important to understand how robust control theory can be applied to describe systems for which an exact mathematical model does not exist. The goal of this course is to examine a number of examples in some detail to gain insight into the dynamics of regulation in biology.

BME 643. Biomedical Imaging-Oncology. 3 Hours.
Advanced and quantitative medical imaging and image processing to understand biological processes related to cancer biology. Medical imaging technology will include molecular, functional and anatomical imaging related to the hallmarks of cancer.

BME 655. NextGen BioMed-Research Technologies and Skills. 3 Hours.
The course will provide students with a solid foundation in the principles, methods, and techniques used in biomedical research. The course will cover a range of topics, including experimental design, cell and molecular biology techniques, immunological techniques, animal models and in vivo studies, and laboratory safety and good laboratory practices.

BME 664. Neural Computation. 3 Hours.
This course examines the principal theoretical underpinnings of computation in neural networks. Emphasis will be placed on understanding the relationship between the different approaches: dynamical systems, statistical mechanics, logic, Kalman filters, and likelihood/Bayesian estimation.

BME 665. Computational Vision. 3 Hours.
This course approaches the study of biological and artificial vision from a theoretical perspective beginning with a comparative survey of visual systems and then examining vision algorithms and architectures.

BME 670. Quantitative Physiology. 3 Hours.
Study of physiological problems using advanced mathematical techniques. Topics covered include: mechanics, fluid dynamics, transport, electrophysiology of cell membranes, and control systems.
Prerequisites: BME 517 [Min Grade: C] or BME 617 [Min Grade: C] or BME 717 [Min Grade: C] or ME 661 [Min Grade: C] or ME 761 [Min Grade: C]

BME 672. Cellular Therapy. 3 Hours.
Introduction to research in cellular therapy, its clinical applications, and its potential for commercialization. Students will learn fundamental mechanisms, become familiar with the progress of several successful therapies that use human T cells and stem cells, and learn the challenges and opportunities for future biopharmaceutical and biotechnology industries.

BME 673. Lab Rotation. 3 Hours.
Entering BME graduate students will work in the laboratories of 2 or 3 potential research mentors. The duration of each rotation period will be by mutual agreement between student and faculty but must be at least 4 weeks. The goal is for students to match with their primary research mentor by the end of the course.

BME 677. Fracture Mechanics. 3 Hours.
The course covers linear elastic fracture mechanics, including fatigue crack growth, and nonlinear elastic fracture mechanics. Experimental and computational methods are also introduced.

BME 680. Biomolecular Modeling. 3 Hours.
Molecular modeling principles and applications. Students will perform hands-on exercises using molecular modeling tools and software. Students will learn the critical relationships among structure, function, and thermodynamic driving forces in structural biology and become able to utilize molecular modeling techniques to explore biological phenomena at the molecular level.

BME 690. Special Topics in Biomedical Engineering. 1-6 Hour.
Special Topics in Biomedical Engineering.

BME 691. Individual Study in Biomedical Engineering. 1-6 Hour.
Individual Study in Biomedical Engineering.

BME 693. Internship in Biomedical Engineering. 1-6 Hour.

BME 697. Journal Club. 1-3 Hour.
Journal Club.

BME 698. Non-Thesis Research. 1-12 Hour.

BME 699. Thesis Research. 1-12 Hour.
Prerequisites: GAC M

BME 701. Seminar in Biomedical Engineering. 1 Hour.
Current topics in biomedical engineering technology and applications.

BME 705. Insights to Innovation BME Journal Club. 1 Hour.
Insights to Innovations (i2i) BME Scholar's Pulse is a Journal Club designed to facilitate critical analyses and discussion of current research in the field of biomedical engineering. Students will learn how to conduct literature searches, read and evaluate scientific articles, and present research findings effectively. Students will develop their presentation and discussion skills and gain a deeper understanding of the various subfields of biomedical engineering.

BME 717. Engineering Analysis. 3 Hours.
Advanced ordinary differential equations, transform techniques, scalar and vector field theory, partial differential equations (heat, wave, Laplace).

BME 723. Skin and Bone Regeneration. 3 Hours.
Study of principles of healing, methods to enhance, and clinical applications.

BME 725. Immune-Engineering: Biomaterial Toolbox for Immune-Modulation. 3 Hours.
This course introduces immunology and engineering approaches to study and control immune response using biomaterials. The course is geared towards students/engineers without a deeply established background in immunology. Basic principles in immunology will be covered and contemporary research directions will be discussed based on articles from the primary literature. Biomaterials will be presented as a tool for modifying immune responses.

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This course considers the dynamics of biological systems at a variety of levels from the cell/molecular to the circuit and system levels. Biological systems are typically nonlinear and their behavior is not usually analytically solvable. Yet it is possible to use the tools of nonlinear dynamical systems theory to approach understanding. In addition, it is important to understand how robust control theory can be applied to describe systems for which an exact mathematical model does not exist. The goal of this course is to examine a number of examples in some detail to gain insight into the dynamics of regulation in biology.

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Advanced and quantitative medical imaging and image processing to understand biological processes related to cancer biology. Medical imaging technology will include molecular, functional and anatomical imaging related to the hallmarks of cancer.

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This course approaches the study of biological and artificial vision from a theoretical perspective. We begin with a comparative survey of visual systems, and will examine vision algorithms and architectures.

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Introduction to research in cellular therapy, its clinical applications, and its potential for commercialization. Students will learn fundamental mechanisms, become familiar with the progress of several successful therapies that use human T cells and stem cells, and learn the challenges and opportunities for future biopharmaceutical and biotechnology industries.

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Entering BME graduate students will work in the laboratories of 2 or 3 potential research mentors. The duration of each rotation period will be by mutual agreement between student and faculty, but must be at least 4 weeks. The goal is for students to match with their primary research mentor by the end of the course.

BME 777. Fracture Mechanics. 3 Hours.
The course covers linear elastic fracture mechanics, including fatigue crack growth, and nonlinear elastic fracture mechanics. Experimental and computational methods are also introduced.

BME 780. Biomolecular Modeling. 3 Hours.
Molecular modeling principles and applications. Students will perform hands-on exercises using molecular modeling tools and software. Students will learn the critical relationships among structure, function, and thermodynamic driving forces in structural biology and become able to utilize molecular modeling techniques to explore biological phenomena at the molecular level.

BME 790. Special Topics in Biomedical Engineering. 1-6 Hour.
Special Topics in Biomedical Engineering.

BME 791. Individual Study in Biomedical Engineering. 1-6 Hour.
Individual Study in Biomedical Engineering.

BME 793. Internship in Biomedical Engineering. 1-6 Hour.

BME 797. Journal Club. 1-3 Hour.
Journal Club.

BME 798. Non-Dissertation Research. 1-12 Hour.

BME 799. Dissertation Research. 1-12 Hour.
Prerequisites: GAC Z

CE-Civil Engineering Courses

CE 515. Building Information Modeling (BIM). 3 Hours.
This class provides an introduction to the virtual world of design and construction. Topics covered include uses for technology, what is BIM, and have a focus on AutoCAD and Revit Software. An emphasis is placed on the use of these tools and their practical applications to the real world environment. Students are provided with the software through the Autodesk Student community and are required to complete a Multi-Step term Project.

CE 516. Mechanical Vibrations. 3 Hours.
Free and forced single-degree-of-freedom systems. Multi-degree-of-freedom systems. Damped, forced two-degree-of- freedom systems. Simple continuous systems.

CE 520. Advanced Mechanics. 3 Hours.
Variation of stress at point including determination of principal and maximum shear stresses. Basic problems involving symmetrical deformation; thickwall cylinders, spheres, and rotating disk. Torsions of noncircular sections. Curved beams. Failure Theories. Unsymmetrical bending and shear center.

CE 526. Foundation Engineering. 3 Hours.
Application of principles of soil mechanics to: determine bearing capacity and settlement of spread footings, mats, single piles and pile groups; site investigation, evaluate data from field and laboratory tests; estimation of stresses in soil masses; lateral resistance of piles and pile groups; retaining walls, sheetpiles and coffer-dams.

CE 530. Water Supply/Drainage Design. 3 Hours.
Water requirements; wastewater characteristics. Hydraulics and design of sewers; distribution, and reuse of water. Development of water supplies; design considerations.

CE 530L. Water Supply/Drainage Design Laboratory. 0 Hours.
The laboratory exercises are designed to assist the student in the investigation of water supply and drainage design including the analysis of water networks, pipe network design, storm-water and sewer collection network design, flow path visualization, hydraulic jump, flow over weirs, channel design, and basin modeling. Companion lab to CE 530 and must be taken concurrently.

CE 531. Energy Resources. 3 Hours.
Overview of the various energy resources: oil, natural gas, coal, nuclear, hydro, solar, geothermal, biomass, wind, and ocean energy resources, in terms of supply, distribution, recovery and conversion, environmental impacts, economies, policy, and technology. Concepts and opportunities for energy conservation; including electric power generation, changing role of electric utilities, transportation applications, and energy use in developing countries. Field trips.

CE 533. Solid and Hazardous Wastes Management. 3 Hours.
Overview of waste characterizations, regulations, and management options.

CE 534. Air Quality Modeling and Monitoring. 3 Hours.
Atmospheric pollutants; effects, reactions, and sources. Air pollution meteorology and dispersion modeling. Ambient monitoring.

CE 537. Environmental Experimental Design and Field Sampling. 3 Hours.
Experimental design, sensitivity analyses, water sampling, and flow monitoring. Receiving water chemical reactions. Field investigations.

CE 537L. Environmental Experimental Design and Field Sampling Lab. 0 Hours.
Lab experiences in environmental experimental design and field sampling.

CE 542. Highway Materials and Construction. 3 Hours.
Properties of materials used in highway construction. Construction methods and management.

CE 543. Pavement Design & Construction. 3 Hours.
Analysis of stresses and strains in pavement systems. Design and construction of flexible and rigid pavements, base courses and subgrades. Effects of loading on pavement life.

CE 544. Civil Engineering Analysis II. 3 Hours.
Sampling and experimental design. Hypotheses testing. Decision Analyses. Multiple regression analyses. Nonparametric methods. Analysis of experimental data in civil engineering research; regression, experimental design, non-parametrical analysis.

CE 545. Engineering the Built Environment. 3 Hours.
This service learning course explores the effects the built environment has on urban function, connectivity, community health, and the well-being of its residents. Students work directly in Birmingham neighborhoods learning how to assess different components of the built environment, including transportation, green spaces, lighting, and blight, and to estimate their impacts on community health and well-being. Students then work with representatives from the city, neighborhoods, and local industry to propose engineering solutions, develop realistic cost estimates, assess potential benefits, and develop implementation plans.

CE 546. Green Infrastructure and Transportation. 3 Hours.
This course covers policy and technical issues related to sustainable transportation. The course begins by discussing the concepts, viewpoints, and fundamentals essential for understanding sustainable transportation planning. Tools used to assess sustainability of transportation facilities and neighborhoods are introduced next. The course also presents design options in support of green infrastructure and transportation, including livable street design, and traffic calming applications. The course is expected to expand students' knowledge base on sustainable transportation issues and help them understand the concept of sustainable transportation toward the development of sustainable smart cities.

CE 547. Principles of Sustainable Development. 3 Hours.
The course presents the concepts, viewpoints and fundamentals essential for understanding the urban sustainable development agenda. Students will review basic earth sciences to better evaluate the impact our anthropogenic activities have on the natural environment and therefore how to minimize adverse future outcomes. Throughout the course case studies of sustainable developments will be used to illustrate the value, challenges and limitations of this concept. In the end, students will possess the knowledge base needed to help advance sustainable smart cities development.

CE 553. Design of Wood Structures. 3 Hours.
This course will give students an understanding of structural wood materials, both sawn lumber and a number of engineered wood materials. The main objective of the course is to learn how to design wood structures using these materials, including the design of beams, columns, connections, roof diaphragms, and shear walls. The requirement of the National Design Specification for Wood Structures will be addressed.

CE 554. Design of Masonry Structures. 3 Hours.
Design and detailing of masonry structures. Nomenclature, properties, and specifications for components. Design of assemblages, simple masonry structures, unreinforced and reinforced elements, and complex masonry structures.

CE 556. Prestressed Concrete Design. 3 Hours.
Principles and concepts of design in prestressed concrete including elasticand ultimate strength analysis for flexural, shear, bond, and deflections. Principles of concordance and linear transformation for indeterminate prestressed structures.

CE 557. Concrete Technology. 3 Hours.
Properties of concrete in relation to specifying, purchasing, and evaluating concrete materials. Fresh and hardened concrete properties. Concrete mix design procedures. Effects of finishing, curing, weather conditions, and various construction procedures. Ready mix concrete production and field placement techniques. Specifications writing to ensure good quality concrete and field inspection procedures. Case studies of problems in concrete construction.

CE 560. Structural Mechanics. 3 Hours.
Elastic beam deflections, beam columns, lateral torsional buckling, column stability, plastic design, plate bending, yield line theory.

CE 561. Introduction to the Finite Element Method. 3 Hours.
Concepts and applications of the finite element method. Development and applications of basic finite elements. Software use.

CE 562. Advanced Structural Analysis. 3 Hours.
Analysis of indeterminate structures using classical and matrix methods. Use of large-scale computer programs.

CE 564. Structural Dynamics. 3 Hours.
Closed form and numerical solutions to single-degree-of-freedom structural models. Analysis of multistory frames. Computer application and seismic analysis. Techniques of modal analysis.

CE 565. CE Construction Documents. 3 Hours.
Introduction to Civil Engineering design and construction documents including drawings, specifications, contracts, and testing reports. Overview of civil infrastructure and project types, including the civil engineer's role in the preparation, certification, and use of construction documents. Construction topics include measurement, quantity estimating, and engineering budgets.

CE 567. Wind and Seismic Loads. 3 Hours.
Methods for calculating loads on structures caused by extreme winds and earthquakes. Calculation of wind loads on various types of structures according to theory and codes. Determination of earthquake loads on structures using structural dynamics and codes.

CE 568. Bridge Engineering. 3 Hours.
Bridge loads, steel beam bridges, composite beam bridges, bridge bearings, reinforced and prestressed concrete slab and T-beam bridges, bridge evaluations and ratings, upgrade methodologies, computer applications.

CE 570. International Research Experience. 3 Hours.
The International Research Experience for Students (IRES) program provides the opportunity for undergraduate and graduate students to participate in hands-on engineering research in an international setting. Students perform research on an approved topic related to civil engineering design in an international environment. Students select a topic, perform a detailed literature review, and work with mentors from UAB and the international host institution to develop research objectives and a detailed research plan. The course will culminate in a 6-8 week visit to the international host institution, during which time students will conduct hands-on research with their mentors and prepare final reports.

CE 575. Construction Safety and Health Management. 3 Hours.
This course covers various causes of construction accidents and the adopted strategies to prevent worksite injuries and illnesses. Other topics covered include workers' compensation, OSHA standards for the construction industry, economics of construction safety management, temporary structures, system safety, ergonomic applications, health hazards, and the development of a safety program.

CE 580. Introduction to Water and Wastewater Treatment. 3 Hours.
Physical unit operations, and chemical/biological unit processes for water and wastewater treatment. Design of facilities for treatment. Treatment and disposal of sludge.

CE 585. Engineering Hydrology. 3 Hours.
Hydrologic principles including hydrology cycle, precipitation data, and stream-flow measurements. Applications to engineering problems; stream-flow analysis and watershed management.

CE 590. Special Topics in Civil Engineering. 1-6 Hour.
Special Topic in Civil Engineering.

CE 591. Individual Study in Civil Engineering. 1-6 Hour.
Individual Study in Civil Engineering.

CE 597. Construction Engineering Management. 3 Hours.
Study of construction management services that include: project planning, scheduling, estimating, budgeting, contract administration, agreements, and ethics. Emphasis is made on the management of manpower, materials, money and machinery.

CE 600. Sustainable Construction. 3 Hours.
Study of sustainable construction techniques and best practices. Provides an understanding of the interdependencies between planning, designing, building, operating, and demolishing the built environment and their impacts on the natural environment. Course topics will include: (1) issues of recourse efficiency, economics, ethics, waste, human health, environmental justice, and industrial ecology; (2) alternative practices that significantly reduce adverse environmental impacts of built infrastructure, and (3) explore past and present thinking of engineering practitioners in this newly emerging discipline.

CE 605. Project Management. 3 Hours.
Presents the theory and practice of project management as a distinct discipline with applications in time, cost, and performance management. Managerial, organizational, behavioral and cost benefit aspects of project management are covered, as well as various applied models for organizing, executing, and monitoring a project. Basic estimating techniques to determine cost and time for construction work packages are discussed followed by scheduling model techniques to include the Critical Path Method (CPM), Precedence Diagramming Method (PDM), Program Evaluation and Review Technique (PERT), and Gantt charts.

CE 607. Engineering Entrepreneurship. 3 Hours.
Course focuses on the entrepreneurial engineer--a new type of engineer who needs a broad range of business skills and knowledge above and beyond a strong science and engineering background. The course will introduce engineering students to the key aspects of engineering entrepreneurship including business planning, solving problems, risk taking, financing, marketing, and entrepreneurial leadership. The students will also be introduced to the many opportunities and challenges that accompany starting and operating an entrepreneurial venture. Entrepreneurial company leaders will present their experiences and share their leadership styles as part of the course.

CE 608. Green Building Design. 3 Hours.
Quantitative introduction to the principles of "Green Building Design". Provides students an understanding of the interdependencies between economics, technology, design, building occupation and the subsequent impact on the natural environment. Course will emphasize green building materials, new technologies, and sustainable construction methods. Course also includes LEED Case Studies (industrial, commercial, residential, and institutional examples).

CE 610. The Engineered Environment. 3 Hours.
Fundamentals of environmental engineering as they apply to the construction of the built environment and contemporary issues faced by engineers in developing nations such as Egypt. Topics include air pollution, solid waste management, water treatment, environmental ethics, etc.

CE 612. Theory of Elasticity. 3 Hours.
Equations of linear reduction to plane stress, plane strain, and generalized plane strain. Airy and love stress functions in solution of problems.

CE 615. Theory of Elastic Stability. 3 Hours.
Static stability of bars, beams, trusses, and rigid frames. Dynamic stability of bars. Energy method applied to bucking problems. General theory of elastic stability.

CE 617. Theory of Plates and Shells. 3 Hours.
Linear theory and solutions of plates and various shapes. Large deflection theory and solutions of rectangular and circular plates. Membrane and bending theories of shells. Solutions of problems in conical, cylindrical, and spherical shell.

CE 621. Transportation Engineering Seminar. 1 Hour.
Seminar focusing on student research and guest presentations of various topics of interest to graduate transportation engineering students.

CE 622. Traffic Flow Theory. 3 Hours.
Microscopic and macroscopic traffic flow characteristics. Traffic flow analytical techniques including car-following models, traffic stream models, shock wave analysis, queuing analysis and gap acceptance. Simulation models for network analysis.

CE 623. Non-Motorized Transportation Design and Planning. 3 Hours.
Urban planning principles that support non-motorized transportation, local bicycle or pedestrian plans, non-motorized transportation safety related considerations, non-motorized transportation design including traffic calming techniques, procedures for capacity analysis of pedestrian facilities.

CE 624. Simulation Models for Transportation Applications. 3 Hours.
Basic concepts of simulation models for analysis and optimization of transportation systems. Experimentation with planning simulation models and traffic models for signal timing and capacity analysis.

CE 625. Intelligent Transportation Systems. 3 Hours.
Legal, institutional and planning issues related to intelligent transportation systems. System architecture, communication techniques, advanced user services, intermodal systems, connected and autonomous vehicles applications.

CE 631. Environmental Law. 3 Hours.
Law as it applies to the practicing environmental engineer. New and emerging regulations.

CE 632. Industrial Waste and Wastewater Treatment. 3 Hours.
Solid wastes and wastewaters from various industries. Assessment of treatability, system design, and equipment selection.

CE 633. Solid and Hazardous Waste Management. 3 Hours.
Provides students a quantitative introduction to solid and hazardous waste characterizations, international regulations, and management options. Course topics to include (1) Solid waste management hierarchy (reduce, reuse, recycle, recovery, responsible disposal); (2) Dry tomb landfill design; and (3) Hazardous waste identification and treatment/disposal.

CE 636. Stormwater Pollution Management. 3 Hours.
Quality and quantity of stormwater. Receiving water problems and sources of pollutants. Runoff quality and quantity characterizations. Erosion control. Selection and design of controls; regulations.

CE 638. Water and Wastewater Chemistry. 3 Hours.
Aquatic chemistry. Chemical behavior of pollutants in receiving waters. Fate of common pollutants. Chemical kinetics in natural waters. Photochemical reactions. Modeling of wastewater discharges.

CE 639. Sediment Sources and Controls. 3 Hours.
Erosion and sediment transport areas; design of common erosion control practices.

CE 640. Wastewater Treatment Engineering. 3 Hours.
Wastewater sources and characteristics. Design and operation of wastewater treatment facilities, including grit removal, oil and grease removal, dissolved air flotation, activated sludge process, trickling filters, and rotating biological contractors, stabilization ponds and aerated lagoons, anaerobic processes for wastewater treatment and sludge digestion. Ultimate disposal of wastewater residues and considerations of discharge criteria.

CE 643. Pavement Design and Construction. 3 Hours.
Design and construction of flexible and rigid pavements. Topics include stress and strain responses, design parameters, AASHTO and NAPA design procedures, pavement construction, pavement rehabilitation, and maintenance techniques.

CE 646. Traffic Engineering Operations. 3 Hours.
Highway and intersection capacity analysis, traffic signal timing and phasing, signal coordination, freeway operations, non-signalized traffic control techniques.

CE 648. Urban and Transportation Planning. 3 Hours.
Land use planning for transportation systems; trip generation, trip distribution, modal split, and traffic assignment.

CE 649. Engineering Liability. 3 Hours.
Laws related to liability for engineering design in the context of product liability and construction projects; roles and liabilities between various parties involved in construction projects.

CE 650. Advanced Structural Steel. 3 Hours.
Beams, columns, tension members, and connections; current research.

CE 655. Advanced Reinforced Concrete. 3 Hours.
Beam, column, and slab actions; current research.

CE 658. Engineering Management. 3 Hours.
Management techniques for the practicing engineer.

CE 663. Finite Element Methods. 3 Hours.
Theory and applications in structural mechanics. Plane stress, plane strain, axisymmetric problems, solids, plates, shells, nonlinear systems.

CE 681. Environmental Chemistry. 3 Hours.
Chemical equilibrium, acid/base, chemical concepts in pollutant behavior. Chemical kinetics, redox system, hydrolysis, pesticides, chemical wastes.

CE 682. Water Treatment Engineering. 3 Hours.
Water sources and characteristics. Design and operations of water treatment facilities. Topics Include lime softening operations, coagulation, flocculation, clarification dissolved air flotation, filtration, disinfection, absorption, ion exchange and sludge management.

CE 683. Water and Wastewater Treatment Processes Lab. 3 Hours.
Construction and evaluation of bench-scale treatment processes. Treatability of water and wastewater. Coagulation of sedimentation, settleability of biological sludge, aerobic biological treatment, chemical treatment, water softening toxicity, disinfection, and sludge treatment processes.

CE 685. Engineering Hydrology. 3 Hours.
Hydrologic principles including hydrologic cycle, precipitation data, and stream-flow measurements. Applications to engineering problems; stream-flow analysis and watershed management.

CE 686. Engineering Hydrogeology. 3 Hours.
Groundwater movement, natural quality, contamination, and restoration. Physical and chemical properties of groundwater. Well hydraulics and flow net analyses. Prevention and control of groundwater contamination.

CE 687. Stormwater Detention Pond Design. 3 Hours.
Stormwater problems and control methods. Urban hydrology prediction procedures for drainage and water quality studies. Detention pond design basics, limitations and multiple benefits.

CE 688. Strategic Management and Leadership Applications in a Global Environment. 3 Hours.
This course is designed to prepare students to face the demanding management and leadership challenges facing construction and engineering industry leaders as competition becomes ever more globalized. The necessity to personally remain trained and relevant in the changing business environment is emphasized. Strategic planning, management and leadership in the built environment requires savvy leaders with exceptionally developed analytical and communications skills suitable for multi-disciplinary and multi-national ventures. Every individual and organization must continually innovate and reinvent to stay competitive. In a competitive environment, a strong working knowledge of the financial markets is essential and students are exposed to multiple lessons presented by financial industry practitioners. Students participate in a group project designed to reinforce the methodology associated with preparing and presenting a dynamic business plan. This course provides the opportunity for students to discuss and research these concepts and to recognize the necessity to think independently, challenge conventional thinking, and visualize alternatives.
Prerequisites: CE 669 [Min Grade: C]

CE 689. Building Information modeling (BIM) Techniques. 3 Hours.
This course provides students with an overview of the evolution of BIM technology in the construction industry followed by hands-on training in the basic application of contemporary BIM software. Students will learn basic modeling skills and how to produce graphical presentations. Advanced applications of BIM technology are discussed and demonstrated. Students will be provided with BIM software and are required to complete a multi-step BIM model as a term project.

CE 690. Special Topics in (Area). 1-3 Hour.
Special Topics (Area).

CE 691. Individual Study in (Area). 1-4 Hour.
Individual Study (Area).

CE 692. CE Capstone Project. 3 Hours.
This course covers specific contemporary topics related to civil engineering practice and knowledge. Capstone project using case studies to apply skills, knowledge, techniques, and concepts developed in prior courses.

CE 693. Applied Research in Civil, Construction, and Environmental Engineering. 3-9 Hours.
Research tools, including elements of experimental design and proposal preparation. Effective communication, literature searches, and exploratory data analysis.

CE 695. International Construction Contracts/Liability. 3 Hours.
Provides an overview of the fundamental aspects of the law that affects construction and engineering companies as well as the project owners. Particular emphasis is placed on contract forms and provisions related to liability for engineering design and construction companies, the roles of the typical participation in the process, and dispute resolution.

CE 697. Master's Project. 3-9 Hours.
A UAB Master's Project must demonstrate evidence of scholarly study and writing that ultimately contributes to the scientific knowledge base. This course is designed to allow students the opportunity to develop original ideas or seek to advance knowledge through theory, conceptualization, design, testing of tools, instruments, or procedures relevant to the practice of civil engineering.

CE 698. Non-Thesis Research. 1-12 Hour.

CE 699. Thesis Research. 1-12 Hour.
Prerequisites: GAC M

CE 712. Theory of Elasticity. 3 Hours.
Equations of linear reduction to plane stress, plane strain, and generalized plane strain. Airy and love stress functions in solution of problems.

CE 715. Theory of Elastic Stability. 3 Hours.
Static stability of bars, beams, trusses, and rigid frames. Dynamic stability of bars. Energy method applied to buckling problems. General theory of elastic stability.

CE 717. Theory of Plates and Shells. 3 Hours.
Linear theory and solutions of plates of various shapes. Large deflection theory and solutions of rectangular and circular plates. Membrane and bending theories of shells. Solutions of problems in conical, cylindrical, and spherical shell.

CE 721. Transportation Engineering Seminar. 1 Hour.
Seminar focusing on student research and guest presentation of various topics of interest to graduate transportation engineering students.

CE 722. Traffic Flow Theory. 3 Hours.
Microscopic and macroscopic traffic flow characteristics. Traffic flow analytical techniques including car-following models, traffic stream models, shock wave analysis, queuing analysis and gap acceptance. Simulation models for network analysis.

CE 723. Non-Motorized Transportation Design and Planning. 3 Hours.
Urban planning principles that support non-motorized transportation, local bicycle or pedestrian plans, non-motorized transportation safety related considerations, non-motorized transportation design including traffic calming techniques, procedures for capacity analysis of pedestrian facilities.

CE 724. Simulation Models for Transportation Applications. 3 Hours.
Basic concepts of simulation models for analysis and optimization of transportation systems. Experimentation with planning simulation models and traffic models for signal timing and capacity analysis.

CE 725. Intelligent Transportation Systems. 3 Hours.
Legal, institutional and planning issues related to intelligent transportation systems. System architecture, communication techniques, advanced user services, intermodal systems, connected and autonomous vehicles applications.

CE 731. Environmental Law. 3 Hours.
Law as it applies to the practicing environmental engineer. New and emerging regulations.

CE 732. Industrial Waste and Wastewater Treatment. 3 Hours.
Solid wastes and waste waters from various industries; assessment of treatability, system design, and equipment selection.

CE 736. Stormwater Pollution Management. 3 Hours.
Quality and quantity of stormwater. Receiving water problems and sources of pollutants. Runoff quality and quantity characterizations. Erosion control. Selection and design of controls; regulations.

CE 738. Water and Wastewater Chemistry. 3 Hours.
Aquatic chemistry. Chemical behavior of pollutants in receiving waters. Fate of common pollutants. Chemical kinetics in natural waters. Photochemical reactions. Modeling of wastewater discharges.

CE 739. Sediment Sources and Controls. 3 Hours.
Erosion and sediment transport in urban areas, design of common erosion control practices.

CE 740. Wastewater Treatment Engineering. 3 Hours.
Wastewater sources and characteristics. Design and operation of wastewater treatment facilities, including grit removal, oil and grease removal, dissolved air flotation, activated sludge process, trickling filters, and rotating biological contractors, stabilization ponds and aerated lagoons, anaerobic processes for wastewater treatment and sludge digestion. Ultimate disposal of wastewater residues and considerations of discharge criteria.

CE 749. Engineering Liability. 3 Hours.
Laws related to liability for engineering design in the context of product liability and construction projects; roles and liabilities between various parties involved in construction projects.

CE 750. Advanced Structural Steel. 3 Hours.
Beams, columns, tension members, and connections; current research.

CE 755. Advanced Reinforced Concrete. 3 Hours.
Beam, column, and slab actions; current research.

CE 758. Engineering Management. 3 Hours.
Management techniques for practicing engineers.

CE 763. Finite Element Methods. 3 Hours.
Theory and applications in structural mechanics. Plane stress, plane strain, axisymmetric problems, solids, plates, shells, nonlinear systems.

CE 781. Environmental Chemistry. 3 Hours.
Chemical equilibrium, acid/base, chemical concepts in pollutant behavior. Chemical kinetics, redox system, hydrolysis, pesticides, chemical wastes.

CE 782. Water Treatment Engineering. 3 Hours.
Water sources and characteristics. Design and operation of water treatment facilities including lime softening operations, coagulation, flocculation, clarification, dissolved air flotation, filtration, disinfection, absorption, ion exchange, and sludge disposal.

CE 783. Water and Wastewater Treatment Processes Lab. 3 Hours.
Construction and evaluation of bench-scale treatment processes. Treatability of water and wastewater. Coagulation of sedimentation, settleability of biological sludge, aerobic biological treatment, chemical treatment, water softening toxicity, disinfection, and sludge treatment processes.

CE 786. Engineering Hydrogeology. 3 Hours.
Groundwater movement, natural quality, contamination, and restoration. Physical and chemical properties of groundwater. Well hydraulics and flow net analyses. Prevention and control of groundwater contamination.

CE 787. Stormwater Detention Pond Design. 3 Hours.
Stormwater problems and control methods. Urban hydrology prediction procedures for drainage and water quality studies. Detention pond design basics, limitations and multiple benefits.

CE 790. Special Topics in (Area). 1-3 Hour.
Special Topics in (Area).

CE 791. Individual Studies (In Area). 1-4 Hour.
Individual Studies in (Area).

CE 793. Applied Research in Civil and Environmental Engineering. 3 Hours.
Research tools, including elements of experimental design and proposal preparation. Effective communication, literature searches, and exploratory data analysis.

CE 797. Civil, Construction, and Environmental Engineering Internship. 6 Hours.
Off-campus internship experience working with industries, utilities, or government agencies. Students taking this course will not be allowed to apply Special Topics or Individual Studies courses toward degree requirements.

CE 798. Non-Dissertation Research. 1-12 Hour.

CE 799. Dissertation Research. 1-12 Hour.
Prerequisites: GAC Z

CECM-Construction Egr Mgmnt Courses

CECM 669. Advanced Project Management. 3 Hours.
Skills generally required for sound project management in a variety of management settings are studied in addition to specific management issues typically associated with engineering and construction companies. Students are introduced to the Project Management Institute's Body of Knowledge (PMBOK). A discussion of corporate organizational structures and the evolving use of project management processes helps establish an appreciation for the role of a Project Manager. The elements of a project and the role and responsibilities of the Project Manager are studied in depth. Students are also acquainted with risk management concepts, financial, labor, safety, equipment, and contracting issues facing managers in the engineering and construction environment. Particular emphasis is placed on individual management strengths and weaknesses, team building, and characteristics of successful companies. One of the primary vehicles for discussion will be small case studies from real companies and the outside reading of one or two relevant topical books.

CECM 670. Construction Estimating and Bidding. 3 Hours.
Provides an overview of typical construction delivery systems and the planning and contracting associated with each. A broad study of estimating methodologies ranging from rough "ball park" estimates to detailed unit pricing is presented focusing on labor, equipment, materials, subcontractors, job conditions, location, overhead, and profit. This course is intended to establish a basic understanding of the estimating process; and therefore, substantial course focus will be placed on the term group project.

CECM 671. Construction Liability & Contracts. 3 Hours.
This course provides an overview of the fundamental aspects of the laws that affect construction and engineering companies as well as the project owners. Particular emphasis is placed on contract forms and provisions related to liability for engineering design and construction companies, the roles of the typical participation in the process, and dispute resolution. Students will learn the importance of contract language negotiations and the impact of project risk transfer.

CECM 672. Construction Methods and Equipment. 3 Hours.
This course provides students a big-picture understanding of the construction methods employed to bring the concepts and designs of architects and engineers to physical reality. The importance of building codes is presented in the course material. Detailed study of typical building materials, design details, and construction methods are presented in a logical sequence. Students will understand the planning and deployment of equipment, materials, labor, and subcontractors using a variety of building material and system types. This course provides a necessary baseline of knowledge, vocabulary, and understanding of the role and activities of the designers, engineers, material suppliers, inspectors, and constructors in the commercial building process.

CECM 673. Project Planning and Control. 3 Hours.
This course provides a thorough understanding of the project scheduling process in construction planning and control. Students learn the relationship between the work breakdown structure, organization breakdown structure, and the activities used in developing project schedules. The Critical Path Method (CPM), Precedence Diagram Method (PDM), Program Evaluation and Review Technique (PERT), and Line of Balance (LOB) scheduling methods are discussed in detail to include hand calculations and powerful computer software products. The use of scheduling techniques for project control, resources constraint management, cash flow management, risk management, and project completion date management are investigated as is the importance of communications in the planning and monitoring/controlling processes. Students will experience hands on use with Primavera scheduling software.

CECM 674. Green Building Design/Construction. 3 Hours.
The course addresses the key concepts, viewpoints and fundamentals essential for understanding green building and construction. Materials are focused on how key stakeholders and their future collaborations can begin to incorporate sustainable construction practices for the betterment of the project (new construction and inventory rehabilitation). The course will include instruction suitable to prepare students for the United States Green Building Council (USGBC) Leadership in Energy and Environmental Design (LEED©) Green Associates certification exam.

CECM 675. Advanced Construction and Engineering Economics. 3 Hours.
This course provides an extensive overview of financial and managerial accounting concepts for non-financial managers. Students will learn the basic elements of accounting (Generally Accepted Accounting Practices (GAAP)). They will understand how typical financial records and financial statements are established for companies. Once the basics are understood, students will study how financial data is used for internal cost controlling, planning, and budgeting. Fundamental financial calculations associated with the time value of money, debt instruments, taxes, inflation, and cash flow estimates are emphasized. Students will be expected to demonstrate proficiency in the use of Excel business functions in solving financial problems.

CECM 676. Construction Project Risk Management. 3 Hours.
This course addresses the methodologies employed in the engineering and construction industries to assist in rational decision-making in the face of uncertainty. The course reviews the fundamentals of common probabilistic theories and models, data sampling, hypothesis testing and the basics of Bayesian Decision Theory. In addition, basic financial analysis tools will be reviewed. Theoretical models will then be applied to specific examples encountered in engineering and construction decision making with emphasis on engineering economics applications.

CECM 688. Construction Management and Leadership Challenges in the Global Environment. 3 Hours.
This course is designed to prepare students to face the demanding management and leadership challenges facing construction and engineering industry leaders as competition becomes ever more globalized. The necessity to personally remain trained and relevant in the changing business environment is emphasized. Strategic planning, management and leadership in the built environment requires savvy leaders with exceptionally developed analytical and communications skills suitable for multi-disciplinary and multi-national ventures. Every individual and organization must continually innovate and reinvent to stay competitive. Students participate in a group project designed to reinforce the methodology associated with preparing and presenting a dynamic business plan. This course will provide the opportunity for students to discuss and research these concepts and to recognize the necessity to think independently, challenge conventional thinking, and visualize alternatives.

CECM 689. Building Information Modeling (BIM) Techniques. 3 Hours.
This course provides students with an overview of the evolution of BIM technology in the construction industry followed by hands-on training in the basic application of contemporary BIM software. Students will learn basic modeling skills and how to produce graphical presentations. Advanced applications of BIM technology will be discussed and demonstrated. Students will be provided with BIM software and will be required to complete a multi-step BIM model as a term project.

CESC-Sustainable Smart Cities Courses

CESC 600. Principles of Sustainable Development. 3 Hours.
The course will begin by discussing the concepts, viewpoints and fundamentals essential for understanding urban sustainable development agenda. This will be followed by the evaluation of international conferences and action items proposed by the scientific / professional community to advance sustainable smart cities development. You will review basic earth sciences to better evaluate the impact our anthropogenic activities have on the natural environment and therefore how to minimize adverse future outcomes. Throughout the course case studies of sustainable developments will be used to illustrate the value, challenges and limitations of this concept. In the end, you will possess the knowledge base needed to help advance sustainable smart cities development.

CESC 602. Introduction to Sustainable Smart Cities. 3 Hours.
This course introduces the issues surrounding sustainable development within cities and explores how the smart city concept can contribute to the urban sustainable development agenda. The course begins by considering the key characteristics of contemporary urbanization and the issues and challenges that these present for sustainability and urban environmental management. The meaning and nature of sustainability for cities will be discussed, followed by a consideration of the definitions of a smart city and a discussion of the key elements of a smart city including its contribution to both urban governance and the more effective and efficient management of natural resources. With reference to case studies the final part of the course will explore and evaluate the role that smart city processes and applications can play in enhancing the social, economic and environmental aspects of sustainable development within urban areas.

CESC 604. Low-Carbon and Renewable Energy Systems for Smart Cities. 3 Hours.
As the energy infrastructure is arguably the most important feature in any city energy efficiency and integration of renewable energy sources within urban areas are central to the smart city concept. This course will firstly explore why there is a need for the greater use of low carbon and renewable energy systems within cities, followed by an introduction to the range of low carbon and renewable energy technologies currently available. The course will then move on to introduce the concept of the smart grid and then explore the potential to integrate low carbon and renewable energy systems into smart grids in order to move towards cost-effective, efficient and more environmentally friendly energy provision within cities. Challenges and issues associated with the greater integration of low carbon and renewable energy systems into energy infrastructure within large urban areas will also be considered.

CESC 606. Managing Natural Resources and Sustainable Smart Cities. 3 Hours.
The course examines the challenges of resource use and management within the context of an urbanizing world, exploring how new concepts within the smart and sustainable city agenda may contribute to addressing these challenges. The course begins by considering contemporary patterns of resource use created by cities in the modern world at a variety of scales from the local to the global. New approaches in the form of ecosystem services and urban metabolism in relation to natural resource management are examined in terms of their contribution to developing a smart and sustainable city agenda. The course continues by exploring a selection of key natural resources challenges (e.g. water, energy, air quality and climate) and the development of new management approaches and strategies in these areas. The course concludes by examining the development of integrated environmental management systems and governance structures within which these new approaches can be implemented with reference to a series of case studies.

CESC 608. Green Infrastructure and Transportation. 3 Hours.
The course covers policy and technical issues related to sustainable transportation. The course begins by discussing the concepts, viewpoints and fundamentals essential for understanding sustainable transportation planning. Tools used to assess sustainability of transportation facilities and neighborhoods are introduced next. The course also presents design options in support of green infrastructure and transportation, including livable street design, and traffic calming applications. The course is expected to expand students' knowledge base on sustainable transportation issues and help them understand the concept of sustainable transportation toward the development of sustainable smart cities.

CESC 610. Health and Livability. 3 Hours.
This course will address the multidisciplinary aspects of urban environmental quality and its impact on human well-being. It will provide a critical appreciation of the factors which influence health, well-being and quality of life within contemporary urban environments, demonstrate the importance of genomics and health informatics in developing strategies for improving the health and well-being of urban citizens, explore the importance of urban design and the contribution of the development of food smart cities in improving both urban health and livability, and understand the increasingly important role of Information and Communications Technology (ICT) in facilitating delivery of effective and responsive urban health, well-being, and quality of life strategies.

CESC 612. Green Buildings. 3 Hours.
The course will begin by discussing the concepts, viewpoints and fundamentals essential for understanding green building and construction. Discussions will then be focused on how key stakeholders and their future collaborations can begin to incorporate sustainable construction practices for the betterment of the project (new construction and inventory rehabilitation). This will be followed by the evaluation of sustainable construction rating systems (LEED, BREEAM, etc.) and how they can be applied to occupied buildings throughout an urban environment. Modular case studies of sustainable construction projects (individual structures to entire community developments) will be used to illustrate the value, challenges and limitations of this concept. In the end, students will possess an expanded knowledge base needed to help advance sustainable smart cities development.

CESC 614. Smart Cities Technologies. 3 Hours.
This course gives students the opportunity to study emerging smart technologies that can be deployed and integrated together with the aim of improving overall building / city performance. The course provides an overview of technologies that can be used to: sense and measure physical parameters; acquire, process, and analyze various datasets; and make appropriate decisions / gives suitable instructions based on all available information. Specific technologies addressed include Data Acquisition, Telecommunications, Wireless Sensor Networks, and the Internet of Things. The course will also explore and evaluate how these emerging technologies can contribute to various smart cities / buildings priorities, namely Energy Management, Health, Safety, and Security.

CESC 616. Big Data and Smart Cities. 3 Hours.
The world is becoming increasingly digitally interconnected and this instrumentation, data collection, interconnection, storage, and analysis can provide the capacity to radically transform how cities monitor, manage and enhance their environmental quality and livability. This course will provide an introduction to what big data is and how it can contribute to the smarter, more sustainable management of cities. The course will begin by discussing the concepts of big data and the big data revolution, and an overview of the ways in which data can be captured, stored and analyzed. This will be followed by a consideration of how big data can be used by city managers to optimize: their use of physical and digital infrastructures; their sustainable use of natural resources; citizen service delivery; and citizen engagement, participation and urban governance. You will also be introduced to some of the challenges presented by big data, both the technological challenges and the ethical and social implications associated with collecting, storing and using big data. Throughout the course case studies of big data in action will be used to illustrate the value, challenges and limitations of big data in the smarter, more sustainable management of cities.

CESC 618. Research Methods and Project Planning. 3 Hours.
As a student of smart city processes and urban environmental management you need to understand the research process which enables you to take the knowledge and skills which you have learned and apply it to a specific urban sustainability / environmental management issue. This course is not intended to provide a training in research techniques, but rather to make you aware of a wide range of investigative and analytical methods and techniques using examples drawn from the areas of smart city approaches, urban sustainability and environmental management. Both quantitative and qualitative methodologies and primary and secondary data collection will be covered. You will be encouraged to reflect on the research process and its outcomes by critiquing research papers written from methodological standpoints. You will then apply this knowledge to create a viable research proposal for your own Sustainable Smart Cities Masters project. This proposal will require you to identify and justify for your chosen topic: (i) appropriate research questions, (ii) methodologies and data sampling / collection techniques, (iii) ethical and health and safety implications and, (iv) a timetable of action.

CESC 620. Sustainable Smart Cities Research Project. 0 Hours.
This course will develop skills in both research and technical writing in the area of applying and/or evaluating sustainable smart cities processes and policies to a specific urban environmental or sustainability issue. The research proposal produced as part of the Research Methods and Project Planning course will be implemented. This will involve further research into the relevant background and context of a chosen project topic, implementation and evaluation of appropriate methods for collecting and analyzing data, observations and information, the ability to present findings clearly and concisely, and appreciate their significance in relation to the smart city and sustainable urban management agendas. Research should be at the forefront of student's chosen sustainable smart cities research topic and be at a level similar to that required for acceptance and presentation at a national level conference or symposium on smart and sustainable cities. For students in relevant employment, projects may be carried out in your place of work subject to discussions between you, your employer/line manager, and your project supervisor.

CESE - Structural Engineering Courses

CESE 653. Wood and Masonry Design. 3 Hours.
Design of wood structures to meet the requirements of the National Design Specification including beams, columns, and shear walls. Design and detailing of masonry structures. Nomenclature, properties, and specifications for components. Design of assemblages and masonry elements in simple masonry structures.

CESE 656. Advanced Mechanics of Materials for Structural Engineering. 3 Hours.
This course will review the basic fundamentals of mechanics of materials and will extend the concepts to include 3-dimensional stress and strain, plastic behavior, energy methods, nonlinear behavior, fatigue and fracture, rectangular linear elastic plates, indeterminate structures and stability.

CESE 657. Advanced Design of Steel Structures. 3 Hours.
Design of major components in steel-framed buildings, including composite beams and slabs, beam-columns, moments connections, bracing members, bracing connections, and column base plates.

CESE 659. Advanced Reinforced Concrete. 3 Hours.
In this course students will study the behavior and design of continuous reinforced concrete structures submitted to gravity and lateral loads. The study will include biaxial loading of columns, continuous one-way beams and slabs, two-way floor systems, and torsion loading.

CESE 660. Prestressed Concrete Behavior and Design. 3 Hours.
The course will explore the characteristics and design of pre-stressed concrete structural components to include elastic and ultimate strength analyses for flexural, shear, torsion, deflection, strand bond, and pre-stress loss.

CESE 662. Advanced Structural Analysis. 3 Hours.
This course explores the structural analysis of indeterminate structures using classical and approximate methods and structural analysis software. Specific emphasis is placed on the determination of forces in typical multistory, rectilinear frames subject to gravity and lateral loads. In addition to first order analysis, the course included analysis for second order effects and plastic analysis.

CESE 664. Bridge Engineering. 3 Hours.
This course includes the study of bridge loads, including moving load analysis; methods for approximate structural analysis, preliminary bridge design methods, and the structural design of bridge decks and girders.

CESE 665. Structural Dynamics and Earthquake Engineering. 3 Hours.
This course includes the study of earthquake-induced vibrations of single and multi-degree-of-freedom systems, such as single and multistory frames. Emphasis will be placed on structural steel and reinforced concrete building frames. Response spectrum analysis will be investigated as well as building codes and static and dynamic lateral load force procedures.

CESE 676. Design of Structural Steel Connections. 3 Hours.
Design of bolted and welded steel connections, including shear, moment and brace connections using the AISC Specifications requirements and fundamental engineering principals. Design procedures will be discussed for various structural steel connections. The background and limitations of the design procedures will be reviewed and practical solutions will be provided.

CESE 690. Special Topics (Area). 1-3 Hour.
Special Topics (Area).

CESE 698. Non Thesis Research. 3 Hours.
No syllabus for non-thesis research hours.

EE-Electrical Computer Egr Courses

EE 512. Practical Computer Vision. 3 Hours.
This course covers the fundamentals and application of image analysis. Topics include: image pre-processing, detection, segmentation, classification and recognition, visual tracking, and deep learning.

EE 518. Wireless Communications. 3 Hours.
This course covers the principles and current applications of wireless technology. Topics include propagation models, modulation, multiple access, and channel and signal coding. Applications of wireless for cellular and Internet of Things (IoT) will also be covered.

EE 521. Communication Systems. 3 Hours.
This course covers the mathematics of modulation and demodulation of radio signals to transmit and receive information. It focuses on various forms of amplitude modulation (AM), phase and frequency modulation (FM). This course builds on mathematics from signals and systems course to study how to represent and manipulate the signals in both the time and frequency domain. It also studies the effects of sampling, and how these systems operate in the presence of noise.

EE 523. Digital Signal Processing. 3 Hours.
This course covers the theory and practice of using computers to process and analyze signals. The topics include: digital filter analysis and design; Fast Fourier Transform (FFT) algorithms; applications of digital signal processing in engineering problems such as data acquisition and control.

EE 526. Control Systems. 3 Hours.
This course covers modeling and control of mechanisms or circuits to satisfy stability and performance criteria. Topics include: theory of linear feedback control systems using complex frequency techniques, block diagram manipulation, performance measures, stability, analysis and design using root locus, and Z-transform methods.

EE 527. Industrial Control. 3 Hours.
This course covers power control devices and applications, relay logic and translation to other forms, programmable logic controllers (PLCs), proportional-integral-derivative (PID) and other methods for process control, modern laboratory instrumentation, and human-machine interface (HMI) software.

EE 531. Analog Integrated Electronics. 4 Hours.
This course covers advanced analysis and design using op-amps, differential amplifier, half-circuit analysis, error analysis and compensation. Applications include signal conditioning for instrumentation, instrumentation amplifiers, nonlinear and computational circuits, analog filter design, voltage regulator design, and oscillators, circuit configurations for A-to-D and D-to-A conversion methods. Laboratory exercises emphasize design techniques for projects in areas such as Internet-of-Things (IoT).

EE 532. Introduction to Computer Networking. 3 Hours.
This course covers the fundamentals of modern computer networks including current applications such as Internet of Things (IoT). Topics include: hardware and software level network protocols, network architecture and topology including WANs and LANs, client-server relationships, distributed computing, data transfer, security, virtualization of hardware, multi-tier network configuration examples, and certifications will be addressed.
Prerequisites: EE 134 [Min Grade: C] and EE 210 [Min Grade: C]

EE 533. Engineering Software Solutions. 3 Hours.
This course covers the fundamentals of software design, architecture, and implementation for future software engineers. Topics include: customer-focused requirements gathering, project planning, team tools, architectural patterns, environment and component selection, quality assurance, sustainability, and versioning. Various development methodologies are discussed with a project demonstrating at least one release cycle.

EE 534. Power Semiconductor Electronics. 3 Hours.
This course covers the fundamentals of power electronics such as principles of static power conversions, basic power converter architectures, power semiconductor switches, steady-state equivalent circuit modeling, DC transformer model, basic AC equivalent circuit modeling, linearization and perturbation. Pulse width modulation and controller design, circuit design considerations, and applications of power electronics. The course project emphasizes computer-aided analysis and design of power electronic circuits.

EE 537. Introduction to Embedded Systems. 3 Hours.
This course provides an applied introduction to the design of embedded systems, including hardware and software aspects. Topics include: various embedded hardware platforms, interfacing industrial bus systems, sensors, actuators, low-power wireless communication, and the application of the Internet of Things (IoT).

EE 538. Computer Architecture. 3 Hours.
Advanced microprocessor topics include a comparison of advanced contemporary microprocessors, cache design, pipelining, superscalar architecture, design of control units, microcoding, and parallel processors. Basic knowledge of microprocessors is recommended.

EE 544. Real-Time Process & Protocols. 3 Hours.
This course covers hands-on laboratory topics in real-time computer systems, such as algorithms, state-machine implementations, communication protocols, instrumentation, and hardware interfaces.

EE 547. Internet/Intranet Application Development. 3 Hours.
This course covers development of software models and applications using Internet/Intranet technologies. Topics include: web client-server relationships, multi-tier design models, scripting and validation, basic TCP/IP networking, separation of concerns, markup and data description languages. Projects will allow the opportunity for the use of a range of tools and development platforms.
Prerequisites: EE 233 [Min Grade: C]

EE 548. Software Engineering Projects. 3 Hours.
This course covers practical applications of software engineering including the development of applications for the Internet of Things (IoT). Topics include: requirements gathering, design matrices, environment selection, relevant architectural patterns, networking basics, databases, service endpoints, embedded systems selection and security. Projects with a software emphasis will be utilized to demonstrate the principles of IoT applications.
Prerequisites: EE 333 [Min Grade: C]

EE 552. Digital Systems Design. 3 Hours.
This course covers the design of customized complex digital systems using Field Programmable Gate Array (FPGA) based platforms, using modern design tools for simulation, synthesis, and implementation. Topics include hardware design and development languages such as Verilog or VHDL.

EE 558. Medical Instrumentation. 3 Hours.
This course covers the fundamental operating principles, applications, safety, and design of electronic instrumentation used in the measurement of physiological parameters.

EE 561. Machinery II. 3 Hours.
Physical principles of DC machines. Mathematical analysis of generator designs using equivalent circuits and magnetization curves. Calculation of motor speed, torque, power, efficiency, and starting requirements. Solid-state speed control systems.

EE 563. Medical Image Analysis. 3 Hours.
A lab-based introduction to processing, analysis, and display techniques for medical imaging.

EE 567. Brain Machine Interface. 3 Hours.
This course explores the brain-machine interfaces, particularly the technologies that directly stimulate and/or record neural activity. This course is divided into three major components: 1) neuroscience and electrode interfaces, 2) brain recording and stimulating front-end circuits, and 3) circuit modeling, simulation, and optimization.

EE 568. Introduction to Large Language Models. 3 Hours.
This course provides a foundational understanding of Large Language Models (LLMs), focusing on intuition, practical applications, and hands-on implementation. Students will learn to build, fine-tune, and deploy LLMs using modern tools and APIs such as OpenAI and Anthropic. Ethical considerations are addressed, with an emphasis on technical workflows.

EE 571. Power Systems I. 3 Hours.
Components of power systems. Performance of modern interconnected power systems under normal and abnormal conditions. Calculation of inductive and capacitive reactances of three-phase transmission lines in a steady state.

EE 572. Power Systems II. 3 Hours.
Modeling of generators, transformers, and transmission lines for system studies. Introduction to symmetrical components. Calculation of short-circuit currents due to balanced and unbalanced faults. Determination of interrupting ratings of circuit breakers. Transient stability of power systems. Derivation of swing equation and solution by numerical method. Equal area criterion. A power system design project is required.

EE 573. Protective Relaying of Power Systems. 3 Hours.
Operating principles of protective relays. Protection of transmission lines, generators, motors, transformers, and buses.

EE 585. Engineering Operations. 3 Hours.
This course covers the principles and standard of engineering design from ideation to final design. Topics include: product development process, problem definition and need identification, embodiment and detail design, design for specific criterion, modeling and cost evaluation. Emphasis is placed on ethics and civil responsibilities in design including environmental, social issues, liability, sustainability and reliability through the lens of engineering design.

EE 590. Special Topics in Electrical and Computer Engineering. 1-3 Hour.
Special Topic in Electrical or Computer Engineering.

EE 591. Individual Study in Electrical and Computer Engineering. 1-6 Hour.
Individual Study in Electrical Engineering.

EE 601. Electrical and Computer Engineering Seminar. 1-3 Hour.
This course consists of research presentations delivered by faculty, research assistants, and invited guests in various state-of-the-art and popular topics related to Electrical and Computer Engineering.

EE 610. Technical Communication for Engineers. 3 Hours.
A workshop-oriented course providing students with the opportunity to produce technical memoranda, a proposal, and a conference and/or refereed journal paper and to make oral presentations related to these work products utilizing appropriate software presentation aids.

EE 616. Design of CMOS Analog Integrated Circuits. 3 Hours.
This course will cover the basic building blocks of CMOS analog VLSI design, MOSFET theory, short channel device and nonlinear effects, current mirrors, current-reference generator, operational transconductance amplifier, switched capacitor architecture, analog-to-digital converter and digital-to-analog converter. Students will be required to develop a computer-aided design, simulation, and chip layout of an analog integrated circuit design project. Fundamental knowledge of electronics is required.

EE 621. Random Variables and Processes. 3 Hours.
Theory underlying analysis and design of communication, stochastic control, data gathering, and data analysis systems.
Prerequisites: EE 421 [Min Grade: C]

EE 622. Advanced Communication Theory. 3 Hours.
Analysis of the performance of analog modulation techniques in the presence of noise.
Prerequisites: EE 621 [Min Grade: C]

EE 623. Computer Vision. 3 Hours.
Advanced topics in computer vision: image segmentation, registration, and visual tracking; applications of deep learning to image analysis.

EE 624. Digital Communications. 3 Hours.
Design and analysis of digital communications modulation techniques and systems and their performance in the presence of noise.
Prerequisites: EE 622 [Min Grade: C]

EE 625. Information Theory and Coding. 3 Hours.
Channel models and block codes, block code ensemble performance analysis, convolutional codes and ensemble performance, sequential decoding of convolutional codes.
Prerequisites: EE 621 [Min Grade: C]

EE 626. Digital Image Processing. 3 Hours.
The course covers topics in image transformations, enhancement, restoration, compression, and representation. Introduction to image segmentation.

EE 627. Wireless Communications. 3 Hours.
Wireless communication system topics such as propagation, modulation techniques, multiple access techniques, channel coding, speech and video coding, and wireless computer networks.

EE 630. Short-Range Wireless Systems. 3 Hours.
This course covers short-range wireless power transmission (WPT), wireless data communication, and wireless sensor technologies. It emphasizes fundamental understanding of the principles and design procedure of short-range wireless power/data transfer systems as well as the various parameters involved in the optimization of wireless power/data transmission systems.

EE 632. Introduction to Computer Networking. 3 Hours.
Computer networking fundamentals. Layered network model and correspondence to real systems. Discussion of Ethernet, Token Ring, TCP/IP, LAN, and other protocols. Exploration of the Internet and similar systems. Network application models. Simulation of networks.

EE 633. Experiments in Computer Networking. 3 Hours.
Detailed exploration of particular issues in network protocols and network application models. Development of a series of programs to explore the details of network protocols and network application models.

EE 634. Introduction to Neural Networks. 3 Hours.
Artificial neural network topologies and training algorithms with an emphasis on backpropagation. Deep learning with Convolutional Neural Networks (CNN), Recurrent Neural Networks (RNN), applications and limitations of neural networks, and designing networks specific uses.

EE 636. Advanced Digital Design. 3 Hours.
This course covers the design of Complex Programmable Logic Devices (CPLDs) and Field Programmable Gate Arrays (FPGAs). Topics include the design, simulation, and testing of digital systems using a hardware description language and FPGA/CPLD development boards with programmable logic devices.

EE 637. Design of Modern Computer with Digital Integrated Circuits. 3 Hours.
This course covers the design of advanced digital circuits with VLSI components. Topics include synthesis, design, simulation, and testing of advanced digital circuits using a hardware description language and FPGA/CPLD development boards with programmable logic devices. Design examples: switching networks, graphics engine, DSP, Internet of Things (IoT) controller, and programmable logic controller (PLC).

EE 638. Neural Time Series Data Analysis. 3 Hours.
This course covers the theory and practice of analyzing brain signals. Students will learn about conceptual, mathematical and implementational (via MATLAB programming) aspects of time-, frequency- and synchronization-based analyses of magnetoencephalography (MEG), electroencephalography (EEG), and local field potential (LFP) recordings from humans and nonhuman animals.

EE 639. Embedded Systems. 3 Hours.
This course covers both hardware and software trends in advanced embedded system design, including artificial intelligence (AI) and optimized hardware platforms for machine learning (ML). The fundamental algorithms of AI and ML are discussed. Various process acceleration techniques for improving the computational efficiency of ML kernels are implemented on FPGA/CPLD development boards and FPGA/CPLD chips.

EE 640. Object-Oriented Design. 3 Hours.
This course provides in-depth coverage of object-oriented design principles and methodologies. Topics include object-oriented design frameworks, use-cases, class-responsibility-collaboration (CRC), design patterns, and software reuse. Knowledge of an object-oriented language is recommended.

EE 641. Modern Control Theory. 3 Hours.
This course covers state variable models for continuous-time and discrete-time systems, state feedback and pole placement, and state estimation. Knowledge of basic control systems is recommended.

EE 642. Intelligent Systems. 3 Hours.
This course covers the organization and characteristics of intelligent systems, optimization, evolutionary algorithms, neural networks, fuzzy logic algorithms, and intelligent control.

EE 643. Numerical Methods in Engineering. 3 Hours.
This course covers the theory and practice of numerical methods for a broad spectrum of engineering applications and data analyses. Topics include numerical calculus, linear algebra, and optimization. Students will be exposed to modern topics such as convolutional neural networks, compressed sensing, eigenfaces, stability, principal component analysis, k-means clustering, image segmentation, detection of a signal in the noise, and function fitting. This course provides hands-on practical experience with programming numerical analysis algorithms.

EE 650. Software Engineering. 3 Hours.
This course covers the engineering approach to developing software solutions to real-world problems. Topics include an overview of Software Engineering, requirements elicitation, design, implementation, and an overview of software development methods.

EE 651. Software Engineering Large Systems - I. 3 Hours.
This course covers advanced integrated software systems development methods. Adaptive and prescriptive software systems development methods are covered with an in-depth exploration through team projects using current software development methods.

EE 654. Mobile Computing. 3 Hours.
This course covers the fundamentals and advanced concepts in mobile computing. Develop user interface, application logic, and back-end services, using advanced integrated development environments. Individual and team projects. Programming required.

EE 655. Cloud Computing. 3 Hours.
This course covers fundamental and advanced concepts in cloud computing, including evaluation of current market offerings. Students will also design and implement systems integrating multiple cloud computing services.

EE 656. Introduction to Big Data Analytics. 3 Hours.
This course covers an introduction to the field of big data analytics, including technologies, challenges, architecture, and hypothesis testing.

EE 658. Machine Learning in Engineering. 3 Hours.
This course covers techniques for developing solutions to complex problems in different engineering domains without having to explicitly program the computers. Topics include supervised and unsupervised learning, classification and regression, support vector machines (SVM), boosting, and artificial neural networks.

EE 660. Medical Signal Processing. 3 Hours.
This course covers the theory and practice of processing and analyzing single-channel and multiple-channel medical signals. The topics include linear and nonlinear filtering, cross-estimation, autoregressive and spectral modeling, entropy, principal component analysis (PCA), classification, and clustering methods.

EE 667. Advanced Brain Machine Interface. 3 Hours.
This course consists of four major parts: 1) neuroscience and interfaces, 2) brain imaging technologies, 3) front-end circuit design, 4) power/data links and graphical user interface, and 5) circuit, wireless link, and safety simulating software-learning parts.

EE 668. Large Language Models: Theory and Practice. 3 Hours.
This course provides an in-depth exploration of designing and implementing large language models (LLMs) from scratch. Students will gain a strong theoretical foundation in deep learning architectures, pre-training and fine-tuning strategies, and optimization techniques for scaling LLMs. The course emphasizes hands-on experience, guiding students through implementing transformers, training models on real-world datasets, and deploying efficient inference pipelines. By the end of the course, students will have built their own small-scale LLM.

EE 682. Electromagnetic Field Theory I. 3 Hours.
This course covers the modeling of materials and environments through the simulation of electromagnetic fields. It includes a wide variety of applications, including biomedical and the Internet of Things (IoT). Topics include boundary-value problems and scattering.

EE 690. Special Topics in (Area). 1-6 Hour.
Special topics selected by faculty for master's students.

EE 691. Individual Study in (Area). 1-6 Hour.
Individual study selected by faculty for master's students.

EE 697. Graduate Project. 3 Hours.
Graduate project for Plan II Masters students.

EE 698. Non-Thesis Research. 1-12 Hour.
Individual research in selected area by faculty for master's students.

EE 699. Thesis Research. 1-12 Hour.
Thesis research.
Prerequisites: GAC M

EE 701. Electrical and Computer Engineering Seminar. 1-3 Hour.
This course consists of research presentations delivered by faculty, research assistants, and invited guests in various state-of-the-art and popular topics related to Electrical and Computer Engineering.

EE 710. Technical Communication for Engineers. 3 Hours.
A workshop-oriented course providing students with the opportunity to produce technical memoranda, a proposal, and a conference and/or refereed journal paper and to make oral presentations related to these work products utilizing appropriate software presentation aids.

EE 716. Design of CMOS Analog Integrated Circuits. 3 Hours.
This course will cover basic building blocks of CMOS analog VLSI design, MOSFET theory, short channel device and nonlinear effects, current mirrors, current-reference generator, operational transconductance amplifier, switched capacitor architecture, analog-to-digital converter and digital-to-analog converter. Students will be required to develop a computer aided design, simulation and chip layout of an analog integrated circuit design project. Fundamental knowledge in electronics is required.

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Theory underlying analysis and design of communication, stochastic control, data gathering, and data analysis systems.

EE 722. Advanced Communication Theory. 3 Hours.
Analysis of the performance of analog modulation techniques in presence of noise.

EE 723. Computer Vision. 3 Hours.
Advanced topics in computer vision: Image segmentation, registration, and visual tracking; applications of deep learning to image analysis.

EE 724. Digital Communications. 3 Hours.
Design and analysis of digital communications modulation techniques and systems and their performance in the presence of noise.
Prerequisites: EE 622 [Min Grade: C]

EE 725. Information Theory and Coding. 3 Hours.
Channel models and block codes, block code ensemble performance analysis, convolutional codes and ensemble performance, sequential decoding of convolutional codes.
Prerequisites: EE 621 [Min Grade: C]

EE 726. Digital Image Processing. 3 Hours.
This course covers topics in image transformations, enhancement, restoration, compression, and representation. Introduction to image segmentation.

EE 727. Wireless Communications. 3 Hours.
Wireless communication system topics such as propagation, modulation techniques, multiple access techniques, channel coding, speech and video coding, and wireless computer networks.

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This course covers short-range wireless power transmission (WPT), wireless data communication, and wireless sensor technologies. It emphasizes fundamental understanding of the principles and design procedure of short-range wireless power/data transfer systems as well as the various parameters involved in the optimization of wireless power/data transmission systems.

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Computer networking fundamentals. Layered network model and correspondence to real systems. Discussion of Ethernet, Token Ring, TCP/IP, LAN, and other protocols. Exploration of the Internet and similar systems. Network application models. Simulation of networks.

EE 733. Experiments in Computer Networking. 3 Hours.
Detailed exploration of particular issues in network protocols and network application models. Development of series of programs to explore the details of network protocols and network application models.

EE 734. Introduction to Neural Networks. 3 Hours.
Artificial neural network topologies and training algorithms with an emphasis on backpropagation. Deep learning with Convolutional Neural Networks (CNN), Recurrent Neural Networks (RNN), applications and limitations of neural networks, and designing networks for specific uses.

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This course covers the theory and practice of analyzing brain signals. Students will learn about conceptual, mathematical and implementational (via MATLAB programming) aspects of time-, frequency- and synchronization-based analyses of magnetoencephalography (MEG), electroencephalography (EEG), and local field potential (LFP) recordings from humans and nonhuman animals.

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This course covers both hardware and software trends in advanced embedded system design, including artificial intelligence (AI) and optimized hardware platforms for machine learning (ML). The fundamental algorithms of AI and ML are discussed. Various process acceleration techniques for improving the computational efficiency of ML kernels are implemented on FPGA/CPLD development boards and FPGA/CPLD chips.

EE 740. Object-Oriented Design. 3 Hours.
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This course covers state variable models for continuous-time and discrete time systems, state feedback and pole placement, and state estimation. Knowledge of basic control systems is recommended.

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This course covers the organization and characteristics of intelligent systems, optimization, evolutionary algorithms, neural networks, fuzzy logic algorithms, and intelligent control.

EE 743. Numerical Methods in Engineering. 3 Hours.
This course covers the theory and practice of numerical methods for a broad spectrum of engineering applications and data analyses. Topics include numerical calculus, linear algebra, and optimization. Students will be exposed to modern topics such as convolutional neural networks, compressed sensing, eigenfaces, stability, principal component analysis, k-means clustering, image segmentation with active contours, detection of a signal in the noise, and function fitting. This course provides hands-on practical experience with programming numerical analysis algorithms.

EE 750. Software Engineering. 3 Hours.
This course covers the engineering approach to developing software solutions to real-world problems. Topics include an overview of Software Engineering, requirements elicitation, design, implementation, and an overview of software development methods.

EE 751. Software Engineering Large Systems - I. 3 Hours.
This course covers advanced integrated software systems development methods. Adaptive and prescriptive software systems development methods are covered with an in-depth exploration through team projects using current software development methods.

EE 752. Software Engineering Large Systems - II. 3 Hours.
This course covers software development in enterprise environments using Dev-Ops practices such as continuous integration and delivery.

EE 754. Mobile Computing. 3 Hours.
This course covers the fundamentals and advanced concepts in mobile computing. Develop user interface, application logic, and backend services, using advanced integrated development environments. Individual and team projects. Programming required.

EE 755. Cloud Computing. 3 Hours.
This course covers fundamental and advanced concepts in cloud computing, including evaluation of current market offerings. Students will also design and implement systems integrating multiple cloud computing services.

EE 756. Introduction to Big Data Analytics. 3 Hours.
This course covers an introduction to the field of big data analytics, including technologies, challenges, architecture, and hypothesis testing.

EE 758. Machine Learning in Engineering. 3 Hours.
This course covers techniques for developing solutions to complex problems in different engineering domains without having to explicitly program the computers. Topics include supervised and unsupervised learning, classification and regression, support vector machines(SVM), boosting, and artificial neural networks.

EE 760. Medical Signal Processing. 3 Hours.
This course covers the theory and practice of processing and analyzing single-channel and multiple-channel medical signals. The topics include linear and nonlinear filtering, cross-estimation, autoregressive and spectral modeling, entropy, principal component analysis (PCA), classification, and clustering methods.

EE 767. Advanced Brain Machine Interface. 3 Hours.
This course consists of four major parts: 1) neuroscience interfaces, 2) brain imaging technologies, 3) front-end circuit design, 4) power/data links and graphical user interface, and 5) circuit, wireless link, and safety simulating software-learning parts.

EE 768. Large Language Models: Theory and Practice. 3 Hours.
This course provides an in-depth exploration of designing and implementing large language models (LLMs) from scratch. Students will gain a strong theoretical foundation in deep learning architectures, pre-training and fine-tuning strategies, and optimization techniques for scaling LLMs. The course emphasizes hands-on experience, guiding students through implementing transformers, training models on real-world datasets, and deploying efficient inference pipelines. By the end of the course, students will have built their own small-scale LLM.

EE 781. Electromagnetic Field Theory I. 3 Hours.
This course covers the modeling of materials and environments through the simulation of electromagnetic fields. It includes a wide variety of applications, including biomedical and the Internet of Things (IoT). Topics include boundary-value problems and scattering.

EE 790. Special Topics in (Area). 1-6 Hour.
Special topics selected by faculty for PhD students.

EE 791. Individual Study in (Area). 1-6 Hour.
Individual study in an area selected by faculty for PhD students.

EE 798. Non-Dissertation Research. 1-12 Hour.
Individual research in selected problem by faculty for PhD students.

EE 799. Dissertation Research. 1-12 Hour.
PhD dissertation research.
Prerequisites: GAC Z

EGR-Engineering Courses

EGR 590. Special Topics in Engineering. 1-3 Hour.
Special Topics in Engineering.

EGR 591. Individual Study in Engineering. 1-6 Hour.
Individual Study in Engineering.

EGR 690. Special Topics. 1-4 Hour.

EGR 697. Engineering Grad Internship. 0-6 Hours.
Student works in a professional environment reflective of research interests pursuant to graduate degree.

EGR 698. Non-Thesis Research. 1-12 Hour.
Research allows the student to explore a topic of interest under the close supervision of a faculty member. The course may include directed readings, applied work, in addition to carrying out individual research in selected area.

EGR 699. Thesis Research. 1-12 Hour.
Research allows the student to explore a topic of interest under the close supervision of a faculty member. The course may include directed readings, applied work, in addition to carrying out individual research in selected area.

EGR 710. Intro to Interdisciplinary EGR. 3 Hours.
Introduces current trends and cutting-edge research in areas related to engineering that require interdisciplinary approaches.

EGR 711. Methodology for IEGR Research. 3 Hours.
Presents a detailed perspective on methods of approach for interdisciplinary problems, including experimental design, laboratory experimentation, physical modeling, simulation, and analysis.

EGR 790. Special Topics. 1-4 Hour.

EGR 791. Independent Study. 1-6 Hour.
Independent Study in Engineering.

EGR 792. Interdisciplinary EGR Seminar. 1 Hour.
Discussions and presentations of research involving engineering in a number of disciplines. Required for graduate students in the interdisciplinary engineering Ph.D. program.

EGR 796. Journal Club in Interdisciplinary Engineering. 1 Hour.
Journal club to discuss current research and investigations in areas of interdisciplinary engineering.

EGR 798. Non-Dissertation Research. 0-12 Hours.

EGR 799. Dissertation Research. 1-12 Hour.
Prerequisites: GAC Z

IEM-Information Egr Mgmnt Courses

IEM 601. Introduction to IEM. 1 Hour.
This course is an introduction to Information Engineering and Management with a focus on readiness for graduate study. Program requirements and expectations will be presented. Software and collaboration tools will be introduced. Library access and resources will be reviewed and teams will perform learning exercises to demonstrate proficiency with the available tools.

IEM 602. Leading Collaborative Teams. 1 Hour.
This course will focus on building, leading, and evaluating collaborative teams. Topics will include managing geographically-dispersed teams, team communication, accountability, running effective meetings, facilitation skills, building consensus, and handling common problems.
Prerequisites: IEM 601 [Min Grade: C]

IEM 603. Communication for Technology Executives. 1 Hour.
This course will address communication issues unique to organizational executives. Topics will include functioning as the public face of the organization, working with the media, when to seek professional advice, and effective crisis management.
Prerequisites: IEM 602 [Min Grade: C]

IEM 610. Communication for Technology Professionals. 3 Hours.
This course focuses on recognizing, developing, and putting into practice effective communication skills. Lectures provide insights into presentation structure, style, and content. Self-evaluation exercises combined with personal coaching will help clients improve their professional speaking and presentation skills.

IEM 611. Leading Technical Organizations. 3 Hours.
This course will use case studies, assigned readings, guest lecturers, research projects, and discussion of current issues in technology to develop executive-level behaviors and thought-processes as preparation for starting or leading a technology organization.

IEM 612. Project Leadership. 3 Hours.
This course teaches the fundamental concepts of leading projects. The course will consider all aspects of project leadership including the use of standard methodologies. Best practices will be reviewed along with practical insights based on real-world project leadership experience.

IEM 620. Technical Entrepreneurship. 3 Hours.
This course is an introduction to entrepreneurship that begins with the development of personal insights and work habits that are fundamental to success within any organization.

IEM 625. Technology and Innovation. 3 Hours.
This course examines technological innovation as an element of organizational strategy. Topics include the nature and management of innovation, aligning technical teams with overall organizational strategy, and the role of innovation in launching and sustaining technology ventures.

IEM 630. Systems Engineering. 3 Hours.
This course focuses on the systems engineering lifecycle and its application to the design of complex systems. Topics include systems thinking, managing complexity, problem definition, solution design, solution implementation, quality assurance, and measuring effectiveness.

IEM 631. Operational Decision-Making. 3 Hours.
This course focuses on the critical role of information and analytical methods in optimizing operational decisions. A core set of analytical tools will be presented and discussed. Topics will include decision analysis, optimization, modeling, simulation, and data analysis.

IEM 645. Financial Concepts for Entrepreneurs. 3 Hours.
This course introduces financial concepts including the interpretation of financial statements, managing cash flow, time value of money, capital budgeting, and investment analysis.

IEM 646. Strategic Planning. 3 Hours.
This course will examine the nature of strategic thinking and the challenges of achieving strategic alignment. Topics will include the strategic planning process and methods for assessing strategic success.

IEM 690. Special Topics in Area. 1-3 Hour.
Special Topics in (Area).

IEM 695. IEM Design Project. 3 Hours.
This course is focused upon a final design project that incorporates the technical and entrepreneurial coursework taken previously. Projects will be assessed based on their technical design and financial justification.

IEM 696. IEM Internship. 1-3 Hour.
This course is available for students needing to register for an internship course while enrolled in the IEM program.

ME-Mechanical Engineering Courses

ME 511. Intermediate Fluid Mechanics. 3 Hours.
Applications of fluid dynamic principles to engineering flow problems such as turbo-machinery flow and one-dimensional compressible flow. Vorticity, potential flow, viscous flow, Navier-Stokes solutions, and boundary layers. Introduction to Fluid Mechanics or equivalent is a recommended prerequisite for this course.

ME 521. Introduction to Computational Fluid Dynamics Basics. 3 Hours.
Governing equations for fluid flows, classifications of flow regimes, and approaches to analyze fluid flow problems. Introduction to Computational Fluid Dynamics (CFD), mesh generation, boundary conditions, numerical solution of equations governing fluid flows, and visualization. Hands-on exercises using a commercial CFD solver.

ME 530. Vehicular Dynamics. 3 Hours.
Introduction to the fundamentals of mechanics and analytical methods for modeling vehicle dynamics and performance. Topics include tire-road interaction modeling, vehicle longitudinal dynamics and traction performance, lateral dynamics, handling, stability of motion and rollover, as well as contribution of the drivetrain system, steering system and suspension configurations to the dynamics of a vehicle. Software applications, projects, and exposure to hardware and systems are used to reinforce concepts. Dynamics or equivalent is a recommended prerequisite for this course.

ME 531. Introduction to Vehicle Drive Systems Engineering. 3 Hours.
Engineering fundamentals of mechanical and mechatronic, hybrid-electric, and electric drive systems. Applications to passenger cars and commercial vehicles. Drive system and component design, including main clutches and torque converters, transmissions, transfer cases, and drive axles. Introduction to plug-in hybrid-electric vehicles. Students registering for this course should have successfully completed (grade C or better) ME 215 Dynamics and ME 370 Kinematics and Dynamics of Machinery or equivalents.
Prerequisites: ME 215 [Min Grade: C] and ME 370 [Min Grade: C](Can be taken Concurrently)

ME 532. Introduction to Electric Vehicles. 3 Hours.
Introduction to fully electric and hybrid vehicle engineering. Mechatronic system and component design. Batteries and energy storage devices. Plug-in hybrid electric vehicles.

ME 545. Combustion. 3 Hours.
Evaluation of the impact of fuel characteristics and operating conditions on the performance of coal-fired electric utility steam-raising plant and the prospects for continued reliance on coal as fuel for electric power generation. The phenomena emphasized are the behavior of turbulent jets; ignition, devolatilization and combustion of coal particles; radiative heat transfer and the effect of ash deposits on heat transfer; formation of air pollutants and their removal from combustion products; integrated gasification combined cycle; and capture and sequestration of carbon dioxide. Thermodynamics II, Introduction to Fluid Mechanics, and Introduction to Heat Transfer or equivalents are recommended prerequisites for this course.

ME 547. Internal Combustion Engines. 3 Hours.
Fundamentals of reciprocating internal combustion engines: engine types, engine components, engine design and operating parameters, thermochemistry of fuel-air mixtures, properties of working fluids, ideal models of engine cycles, engine operating characteristics, gas-exchange processes, fuel metering, charge motion within the cylinder, combustion in spark-ignition and compression ignition engines.

ME 549. Power Generation. 3 Hours.
Application of thermodynamics, fluid mechanics, and heat transfer to conversion of useful energy. Includes terrestrial and thermodynamic limitations, fossil fuel power plants, renewable energy sources, and direct energy direct energy conversion. Thermodynamics II or equivalent is a recommended prerequisite for this course.

ME 554. Heating, Ventilating, & AC. 3 Hours.
Fundamentals and practice associated with heating, ventilating, and air conditioning; study of heat and moisture flow in structures, energy consumption, and design of practical systems. Introduction to Heat Transfer or equivalent is a recommended prerequisite for this course.

ME 555. Thermal-Fluid Systems Design. 3 Hours.
Comprehensive design problems requiring engineering decisions and code/Standard compliance. Emphasis on energy system components: piping networks, pumps, heat exchangers. Includes fluid transients and system modeling. Introduction to Heat Transfer is a recommended prerequisite for this course.

ME 556. Building Energy Modeling and Analysis. 3 Hours.
Computer modeling of energy use and thermal comfort in buildings using several software tools. Interpretation and analysis of the results. Implementing energy efficiency measures in the model and studying the effects on energy use. Students registering for this course should have successfully completed (grade of C or better) ME 242 Thermodynamics II and ME 322 Introduction to Heat Transfer or equivalents.

ME 564. Introduction to Finite Element Method. 3 Hours.
Concepts and applications of finite element method. Development and applications of basic elements used in engineering mechanics. Use of finite element analysis software. Application of finite element concept to several areas of mechanics. Mechanics of Solids or equivalent is a recommended prerequisite for this course.

ME 575. Mechanical Vibrations. 3 Hours.
Development of equations of motion for free and forced single-degree-of-freedom (SDOF) systems. Multi-degree-of-freedom systems. Transient response, support motion and vibration isolation for SDOFs. Vibration absorbers, generalized mass and stiffness, orthogonality of normal modes, and root solving and Gauss elimination procedures. Chelosky decomposition and Jacobi diagonalization methods.

ME 577. Systems Engineering. 3 Hours.
Exposure to the field of systems engineering, mission design, requirements development, trade studies, project life cycle, system hierarchy, risk analysis, cost analysis, team organization, design fundamentals, work ethics, compare and evaluate engineering alternatives, systems thinking.

ME 578. Automated Manufacturing. 3 Hours.
Introduction to automated manufacturing technology. Components of automated systems (controllers, sensors and actuators) and automated manufacturing sub-systems (3D printer, CNC, robot and computer vision) will be studied in a lecture\lab environment with hands on activities. A basic understanding of engineering graphics and computer methods at the undergraduate level is required for this course.

ME 580. Instrumentation and Measurements. 3 Hours.
Thorough exploration of fundamental measurement concepts and techniques for data acquisition and validation. Explanation of important selection criteria for the identification and configuration of commercially available data acquisition devices. Students will get hands on experience following best practices for data acquisition (high speed vs low speed) relevant to their field of study or career. Many types of sensors, their underlying technology, and measurement techniques will be discussed (i.e. accelerometers, load cells, Digital Image Correlation, etc.) to demonstrate best practices for sensor selection for a wide range of specialized applications.

ME 590. Special Topics in Mechanical Engineering. 1-3 Hour.
Special Topics in Mechanical Engineering.

ME 591. Individual Study in Mechanical Engineering. 1-6 Hour.
Individual Study in Mechanical Engineering.

ME 611. Advanced Fluid Mechanics. 3 Hours.
Fundamental laws of motion for viscous fluid, classical solutions of the Navier-Stokes equations, inviscid flow solutions, laminar boundary layers, and stability criteria.

ME 613. Introduction to Computational Fluid Dynamics. 3 Hours.
Review of governing equations of fluid dynamics, mathematical behavior of partial differential equations, basic aspects of discretization, basic CFD techniques, basic grid generation, coordinate transformations, advanced numerical schemes, future CFD methodology. A knowledge of a computer language is required.

ME 614. Advanced Computational Fluid Dynamics. 3 Hours.
Finite Volume Scheme, Eigenvalues and Eigenvectors, Method of Characteristics, Upwind Schemes, Flux Vector Splitting, Flux Difference Splitting, Explicit and Implicit Schemes, Flux Jacobians, Newton Method, Boundary Conditions, Weak Solutions, TVD, PISO Methods.

ME 615. Introduction to Turbulent Flows. 3 Hours.
Characteristics of turbulence, length and time scales, energy cascade, vorticity stretching, Reynolds averaging technique, Closure problem, Boussinesq hypothesis, Eddy viscosity concepts, introduction to zero-, one-, and two-equation models, Reynolds stress model.

ME 631. Dynamics and Mobility of Vehicles: Modeling and Simulation. 3 Hours.
The main goal of the course is to present advanced research and engineering knowledge in recent vehicle dynamics of road and off-road wheeled and track vehicles with an emphasis on vehicle longitudinal/lateral mobility and energy efficiency. Applications include vehicles for personal transportation, military vehicles, construction equipment and farm tractors. A unique feature of this course is its inverse vehicle dynamics approach. Another distinctive feature of the course is a mechatronics-based approach to modeling and simulation of multi-domain systems that include mechanical, electrical and electronics components such as sensors and actuators. Coupled and interactive dynamics of vehicle systems is presented, and a modeling process of vehicle operational properties is based on various equations of analytical and adaptive dynamics. Students will gain knowledge and analytical hands-on skills through innovative homework and a research project. Skills in one of programming software/languages are required (e.g., MATLAB/Simulink, ADAMS/Car, LabVIEW, etc.).

ME 632. Autonomous Wheel Power Management Systems: Theory and Design. 3 Hours.
The main goal of this course is to give detailed understanding, analytical knowledge and engineering experience in research, design and experimental study of autonomous wheel power management systems (AWPMS). The AWPMS are autonomous mechatronic and autonomously operated mechanical systems that distribute power among the drive wheels of vehicles. AWPMS include various configurations of torque vectoring systems, limited slip differentials and hydraulically controlled differentials, electronically-locking differentials, and positive engagement of the wheels. AWPMS that are operationally integrated with steering and suspension systems are also presented in the course. Characteristics of wheel power management systems for a specific vehicle application are proved in the course by using inverse vehicle dynamics formulation and requirements to vehicle energy efficiency, mobility, stability of motion, and turnability. Students will learn mechanical design principles for mechatronic systems and methods for developing control algorithms. Methods for experimental study of wheel power management systems and vehicles are also presented in the course; including 4x4 vehicle chassis dynamometer with individual wheel control and test setups. Students will exercise analytical skills and gain hands-on experience through innovative homework and a research project.

ME 640. Heat Conduction. 3 Hours.
Introduction to methods of solution for heat conduction problems. Topics include separation of variables in rectangular, cylindrical and spherical coordinates, solution to the heat equation on semi-infinite and infinite domains, Duhamel's Theorem, use of Green's Function, and use of the Laplace Transform. A basic understanding of heat transfer at the undergraduate level is required for this course.

ME 641. Radiation Heat Transfer. 3 Hours.
Introduction to radiation heat transfer. Topics include radiation from black bodies and nonblack opaque surfaces, configuration factors for diffuse surfaces, radiation exchange in enclosures of diffuse-grey and specularly reflecting surfaces, radiation combined with conduction and convection, and energy transfer for absorbing, emitting and scattering media. A basic understanding of heat transfer at the undergraduate level is required for this course.

ME 650. Transport Phenomena. 3 Hours.
Laminar flow transports: momentum transfer (Couette/Poiseuille flows), energy transfer (free/forced convections and conductions), and mass transfer; equation of state, turbulence, chemical reactions, and numerical methods solving transport equations. Introduction to Fluid Mechanics and Introduction to Heat Transfer or equivalents are recommended prerequisites for this course.

ME 661. Math Methods in EGR I. 3 Hours.
Mathematical theory and solutions methods to problems in engineering including advanced ordinary differential equations; eigenvalue problems; multi-variable calculus and implicit functions; curve, surface ad volume representation and integration; Fourier integrals and transforms; separation of variables and transform techniques for solution of partial differential equations. Differential Equations or equivalent is recommended as a prerequisite for this course.

ME 662. Math Methods in EGR II. 3 Hours.
Mathematical theory and solution methods to problems in engineering including Scalar and vector field theory advanced partial differential equations, analysis using complex variables, conformal mapping, complex integral calculus, Green's functions, perturbation methods, and variational calculus. Math Methods in EGR I or equivalent is recommended as a prerequisite for this course.

ME 663. Engineering Statistics. 2 Hours.
Introduction to applied statistics and probability for engineering and the physical sciences. Topics include introduction to probability, discrete and random variables and their distributions, joint probability distributions, hypothesis testing, statistical inference, linear regression and correlation, design of experiments, and statistical quality control. A basic understanding of calculus and matrix algebra at the undergraduate level is required for this course.

ME 665. Computational Methods in EGR. 3 Hours.
Applications of computers to solution of problems in engineering, including matrices, roots of equations, solution of simultaneous equations, curve fitting by least squares, differentiation and integration, differential and partial differential equations. Differential Equations and Computational Engineering or equivalents are recommended prerequisites for this course.

ME 670. Intro to Continuum Mechanics. 3 Hours.
Fundamentals and application of mechanics principles to problems in continuous media. Matrix and tensor mathematics, fundamentals of stress, kinematics and deformation of motion, conservation equations, constitutive equations and invariance, linear and nonlinear elasticity, classical fluids, linear viscoelasticity. Mechanics of Solids and Differential Equations or equivalents are recommended prerequisites for this course.

ME 672. Advanced Dynamics. 3 Hours.
Advanced topics in dynamics including complex motion analysis, generalized kinematic parameters, quasivelocities, and virtual displacements, direct and inverse dynamics approach, and fundamentals of systems with variable masses. Introduction to the modeling of mechatronic systems is presented through a consideration of mechanical, electrical and electronics components. Analytical and adaptive dynamics principles are taught as a basis for control algorithm development and mechatronic system design.

ME 675. Mechanics of Plates and Shells. 3 Hours.
Equations of motion from classical Kirchoff plate theory, with solutions for cylindrical bending, buckling, and natural vibration of plate strips, rectangular plates and circular plates. Navier, Levy and Rayleigh-Ritz solutions for rectangular plates under various boundary conditions. First and third order shear deformation plate theories with analytical and numerical solutions. Finite element models based on both classical and shear deformation plate theories.

ME 679. Advanced Finite Element Analysis. 3 Hours.
Concepts and applications of finite element method. Development and applications of various elements used in engineering mechanics. Use of finite element analysis software. Application of finite element concept and model development to fluid, heat transfer, and solid mechanics problems. Introduction to Fluid Mechanics, Introduction to Heat Transfer, and Mechanics of Solids or equivalents are recommended prerequisites for this course.

ME 688. Fluid-Structure Interactions. 3 Hours.
Modeling and simulation of fluid-structure interaction (FSI) phenomena using computational methods. The Arbitrary Lagrangian Euleriean (ALE) formulation, a variety of interpolation methods, mesh movement and time mapping algorithms. Solution of FSI problems using interface codes.

ME 690. Special Topics in (Area). 1-6 Hour.
Special Topics in (Area).

ME 691. Individual Study in (Area). 1-6 Hour.
Individual Study In (Area).

ME 698. Non-Thesis Research. 1-12 Hour.

ME 699. Thesis Research. 1-12 Hour.
Prerequisites: GAC M

ME 711. Advanced Fluid Mechanics. 3 Hours.
Fundamental laws of motion for viscous fluid, classical solutions of the Navier-Stokes equations, inviscid flow solutions, laminar boundary layers, and stability criteria.

ME 713. Introduction to Computational Fluid Dynamics. 3 Hours.
Review of governing equations of fluid dynamics, mathematical behavior of partial differential equations, basic aspects of discretization, basic CFD techniques, basic grid generation, coordinate transformation, advanced numerical schemes, future CFD methodology. A knowledge of a computer language is required.

ME 714. Advanced Computational Fluid Dynamics. 3 Hours.
Finite Volume Scheme, Eigenvalues and Eigenvectors, Method of Characteristics, Upwind Schemes, Flux Vector Splitting, Flux Difference Splitting, Explicit and Implicit Schemes, Flux Jacobians. Newton Method, Boundary Conditions, Weak Solutions, TVD, PISD Methods.

ME 715. Introduction to Turbulent Flows. 3 Hours.
Characteristics of turbulence, length and time scales, energy cascade, vorticity stretching, Reynolds averaging techniques. Closure problem, Boussinesq hypothesis, Eddy viscosity concepts, introduction to zero-, one-and two-equation models, Reynolds stress model.

ME 731. Dynamics and Mobility in Vehicles: Modeling and Simulation. 3 Hours.
The main goal of the course is to present advanced research and engineering knowledge in recent vehicle dynamics of road and off-road wheeled and track vehicles with an emphasis on vehicle longitudinal/ lateral mobility and energy efficiency. Applications include vehicles for personal transportation, military vehicles, construction equipment and farm tractors. A unique feature of this course is its inverse vehicle dynamics approach. Another distinctive feature of the course is a mechatronics-based approach to modeling and simulation of multi-domain systems that include mechanical, electrical and electronics components such as sensors and actuators. Coupled and interactive dynamics of vehicle systems is presented, and a modeling process of vehicle operational properties is based on various equations of analytical and adaptive dynamics. Students will gain knowledge and analytical hands-on skills through innovative homework and a research project. Skills in one of programming software/languages are required (e.g., MATLAB/Simulink, ADAMS/Car, LabVIEW, etc.).

ME 732. Autonomous Wheel Power Management Systems: Theory and Design. 3 Hours.
The main goal of this course is to give detailed understanding, analytical knowledge and engineering experience in research, design and experimental study of autonomous wheel power management systems (AWPMS). The AWPMS are autonomous mechatronic and autonomously operated mechanical systems that distribute power among the drive wheels of vehicles. AWPMS include various configurations of torque vectoring systems, limited slip differentials and hydraulically controlled differentials, electronically-locking differentials, and positive engagement of the wheels. AWPMS that are operationally integrated with steering and suspension systems are also presented in the course. Characteristics of wheel power management systems for a specific vehicle application are proved in the course by using inverse vehicle dynamics formulation and requirements to vehicle energy efficiency, mobility, stability of motion, and turnability. Students will learn mechanical design principles for mechatronic systems and methods for developing control algorithms. Methods for experimental study of wheel power management systems and vehicles are also presented in the course; including 4x4 vehicle chassis dynamometer with individual wheel control and test setups. Students will exercise analytical skills and gain hands-on experience through innovative homework and a research project.

ME 740. Heat Conduction. 3 Hours.
Introduction to methods of solution for heat conduction problems. Topics include separation of variables in rectangular, cylindrical and spherical coordinates, solution to the heat equation on semi-infinite and infinite domains, Duhamel's Theorem, use of Green's Function, and use of the Laplace Transform. A basic understanding of heat transfer at the undergraduate level is required for this course.

ME 741. Radiation Heat Transfer. 3 Hours.
Introduction to radiation heat transfer. Topics include radiation from black bodies and nonblack opaque surfaces, configuration factors for diffuse surfaces, radiation exchange in enclosures of diffuse-grey and specularly reflecting surfaces, radiation combined with conduction and convection, and energy transfer for absorbing, emitting and scattering media. A basic understanding of heat transfer at the undergraduate level is required for this course.

ME 750. Transport Phenomena. 3 Hours.
Laminar flow transports: momentum transfer (Couette/Poiseuille flows), energy transfer (free/forced convections and conductions), and mass transfer; equation of state, turbulence, chemical reactions, and numerical methods solving transport equations.

ME 761. Math Methods in EGR I. 3 Hours.
Mathematical theory and solutions methods to problems in engineering including advanced ordinary differential equations; eigenvalue problems; multi-variable calculus and implicit functions; curve, surface ad volume representation and integration; Fourier integrals and transforms; separation of variables and transform techniques for solution of partial differential equations. Differential Equations or equivalent is recommended as a prerequisite for this course.

ME 762. Math Methods in EGR II. 3 Hours.
Mathematical theory and solution methods to problems in engineering including Scalar and vector field theory advanced partial differential equations, analysis using complex variables, conformal mapping, complex integral calculus, Green's functions, perturbation methods, and variational calculus.

ME 763. Engineering Statistics. 3 Hours.
Introduction to applied statistics and probability for engineering and the physical sciences. Topics include introduction to probability, discrete and random variables and their distributions, joint probability distributions, hypothesis testing, statistical inference, linear regression and correlation, design of experiments, and statistical quality control. A basic understanding of calculus and matrix algebra at the undergraduate level is required for this course.

ME 765. Computational Methods in EGR. 3 Hours.
Applications of computers to solution of problems in engineering, including matrices, roots of equations, solution of simultaneous equations, curve fitting by least squares, differentiation and integration, differential and partial differential equations. Differential Equations and Computational Engineering or equivalents are recommended prerequisites for this course.

ME 770. Intro to Continuum Mechanics. 3 Hours.
Fundamentals and application of mechanics principles to problems in continuous media. Matrix and tensor mathematics, fundamentals of stress, kinematics and deformation of motion, conservation equations, constitutive equations and invariance, linear and nonlinear elasticity, classical fluids, linear viscoelasticity. Mechanics of Solids and Differential Equations or equivalents are recommended prerequisites for this course.

ME 772. Advanced Dynamics. 3 Hours.
Advanced topics in dynamics including complex motion analysis, generalized kinematic parameters, quasi-velocities and virtual displacements, direct and inverse dynamics approaches, and fundamentals of systems with variable masses. Introduction to the modeling of mechatronic systems is presented through a consideration of mechanical, electrical, and electronics components. Analytical and adaptive dynamics principles are taught as a basis for control algorithm development and mechatronic system design. Students are expected to have a working knowledge of dynamics prior to registering for this course.

ME 775. Mechanics of Plates and Shells. 3 Hours.
Equations of motion from classical Kirchoff plate theory, with solutions for cylindrical bending, buckling, and natural vibration of plate strips, rectangular plates and circular plates. Navier, Levy and Rayleigh-Ritz solutions for rectangular plates under various boundary conditions. First and third order shear deformation plate theories with analytical and numerical solutions. Finite element models based on both classical and shear deformation plate theories.

ME 779. Advanced Finite Element Analysis. 3 Hours.
Concepts and applications of finite element method. Development and applications of various elements used in engineering mechanics. Use of finite element analysis software. Application of finite element concept and model development to fluid, heat transfer, and solid mechanics problems. Introduction to Fluid Mechanics, Introduction to Heat Transfer, and Mechanics of Solids or equivalents are recommended prerequisites for this course.

ME 788. Fluid-Structure Interactions. 3 Hours.
Modeling and simulation of fluid-structure interaction (FSI) phenomena using computational methods. The Arbitrary Lagrangian Euleriean (ALE) formulation, a variety of interpolation methods, mesh movement and time mapping algorithms. Solution of FSI problems using interface codes.

ME 790. Special Topics in ME. 1-6 Hour.
Special Topics in (Area).

ME 791. Individual Study in (Area). 1-6 Hour.
Individual Study in (Area).

ME 798. Non-Dissertation Research. 1-12 Hour.
Research.

ME 799. Dissertation Research. 1-12 Hour.
Research.
Prerequisites: GAC Z

MME-Materials and Mech Egr Courses

MME 601. Mechanical and Materials Engineering Seminar. 1 Hour.
Seminars by experts in areas of mechanical engineering, materials science and materials/metallurgical engineering will be conducted. The students will get a regular chance to listen and interact with industry engineers/scientists and academic professors outside of the class room experiences and get real-world connectivity in engineering applications.

MME 701. Mechanical and Materials Engineering Seminar. 1 Hour.
Seminars by experts in areas of mechanical engineering, materials science and materials/metallurgical engineering will be conducted. The students will get a regular chance to listen and interact with industry engineers/scientists and academic professors outside of the class room experiences and get real-world connectivity in engineering applications.

MSE-Material Science Egr Courses

MSE 501. Materials Processing. 3 Hours.
Processing of metals, glasses, ceramics, and composites. Powder, casting, welding, rapid solidification, and other advanced approaches.

MSE 505. Frontiers of Automotive Materials. 3 Hours.
Advanced lightweight automotive materials, manufacturing and modeling techniques. Technology advancements in cost-effective carbon, glass and related reinforcements; "green" and sustainable materials, crashworthiness and injury protection of occupants and pedestrians, metal castings, heavy truck, mass transit, fuel cell and hybrid vehicles. Students taking this class will receive a GATE certificate of training in automotive materials technologies upon successful completion.

MSE 508. Nanobiomaterials. 3 Hours.
Basic tools of nanotechnology, building blocks of nanostructured materials. Behavior of materials with nanoscale structures and their technological applications, including automotive, medical, and electronic applications. Introduction to biomaterials and nanobiomaterials, nanotoxicity and how to work safely with nanomaterials. Concepts in tissue engineering with special focus on nanoscaffolds and nanoparticles in drug delivery.

MSE 509. Principles of Metal Casting. 3 Hours.
Production and evaluation of cast ferrous metals (gray iron, ductile iron, steel) and non-ferrous metals (brass, bronze, aluminum). Design of castings and molds. Laboratory on the gating, risering and molten metal treatment, analysis and handling techniques required to produce high quality castings. It is recommended that students who register for this course have successfully completed MSE 280 Engineering Materials or an equivalent course.

MSE 509L. Principles of Metal Casting. 0 Hours.
Laboratory component of MSE 509 and must be taken concurrently.

MSE 513. Composite Materials. 3 Hours.
Processing, structure, and properties of metal-, ceramic-, and polymer-matrix composite materials. Roles of interfacial bond strength, reinforcement type and orientation and matrix selection in physical and mechanical properties of composite materials.

MSE 525. Statistics and Quality. 3 Hours.
This course is arranged to reflect the sequential steps an engineer or scientist take to assess process capability and implement process improvement studies. There is a focus on connecting the theoretical equations to practical examples as well as interpreting and communicating of statistical results.

MSE 530. Polymeric Materials. 3 Hours.
Processing methods, structure/engineering/property relationships, and applications of polymeric materials.

MSE 530L. Polymeric Materials Lab. 0 Hours.
Laboratory component of MSE 530 and must be taken concurrently.

MSE 533. Nondestructive Evaluation of Materials. 3 Hours.
Principles, applications, and limitations of ultrasonic vibrations, acoustic emission, radiographic, magnetic particle, eddy current, and other nondestructive testing methods. Intelligent sensors and health monitoring of real structures.

MSE 545. The Evolution of Engineering Materials. 3 Hours.
Past, present and future of engineering materials; how new materials and processing methods have impacted human society, from the Stone Age until today. Taught as a 3-week study abroad course in Germany, with visits to universities, industrial facilities, research labs, museums and selected cultural sites.

MSE 562. Composites Manufacturing. 3 Hours.
Principles of manufacturing and processing of polymeric matrix composites. Production techniques including filament winding, pultrusion, and liquid infusion techniques combined with design, environmental and manufacturing issues of polymer matrix composites.

MSE 564. Metals and Alloys. 4 Hours.
Microstructures, properties, heat treatment, and processing of ferrous and nonferrous materials.

MSE 564L. Metals and Alloys Lab. 0 Hours.
Laboratory component of MSE 564 and must be taken concurrently.

MSE 565. Characterization of Materials. 4 Hours.
Theory and practice of materials characterization, with emphasis on optical metallography, quantitative metallography, scanning electron microscopy, crystallography, and x-ray diffraction. Specific application in metals and ceramics considered.

MSE 565L. Characterization of Materials Laboratory. 0 Hours.
Laboratory component of MSE 565 and must be taken concurrently with MSE 565.

MSE 570. Ceramic Materials. 4 Hours.
Structure, processing, properties, and uses of ceramic compounds and glasses. Mechanical, thermal, and electrical behavior of ceramic materials in terms of microstructure and processing variables.

MSE 570L. Ceramic Materials Laboratory. 0 Hours.
Laboratory component of MSE 570 and must be taken concurrently.

MSE 574. Metals and Alloys II. 3 Hours.
Production and physical metallurgy of ferrous and non-ferrous alloys including: steel alloys, inoculation and production of ductile, gray, compacted and malleable iron; advanced heat treatments of steel and iron; conventional and ultra-high strength aluminum alloys; wrought and cast copper alloys; wrought and cast magnesium alloys.

MSE 590. Special Topics in Materials Science & Engineering. 1-3 Hour.
Special Topics in Materials Science & Engineering.

MSE 591. Individual Study in Materials Science & Engineering. 1-6 Hour.
Individual Study in Materials Science & Engineering.

MSE 602. Intro to Thermodynamics and Mechanics of Materials. 3 Hours.
This course is a survey of undergraduate level theory and application of the fundamental principles of mechanics of materials and thermodynamics. Understanding is based on the explanation of the physical behavior of materials under load and then modeling this behavior to develop the theory. Intended to provide the students with both the theory and application of the fundamental principles of thermodynamics of materials. Students must be graduate student in engineering, chemistry or physics.

MSE 603. Thermodynamics of Materials. 3 Hours.
Atomistic and classical approaches to the understanding of the thermodynamics of solids, phase transformations, chemical reactions, and alloy systems.

MSE 605. Introduction to Physical Materials. 3 Hours.
Overview of fundamental concepts of materials science and engineering, focusing on chemical and physical properties such as bonding, crystal structure and defects, diffusion, and phase diagrams.

MSE 606. Introduction to Manufacturing Engineering. 3 Hours.
Manufacturing is the process of transforming raw materials into products. Even the most optimized and controlled industrial processes are fraught with variability and inefficiencies, both of which can have a negative impact on profitability. This course will introduce students to the proven tools to characterize and optimize industrial processes. In addition, students will learn the statistical techniques to quantitative assess and detect changes to a process and make data-driven decisions to improve that process.

MSE 607. Measurement Systems Analysis. 3 Hours.
Whether in a manufacturing process, research & development lab or quality control, assessment and analysis of data used for decision making has roots in the equipment and procedures that make up a measurement system. Students will learn to critically assess the capability of measurements systems, gauges and analytical equipment used to collect data. Students will learn metrology, best practices, and statistical tools to quantitatively assess, as well as procedures to implement a Gage R&R study to improve a measurement system. In addition, students will learn effective communication strategies for presenting the results of statistical analysis.

MSE 608. Process Characterization and Advanced Statistical Analysis. 3 Hours.
This course centers on manufacturing processes and the inherent variability of all products. Product variability has origins at all input points in a process; raw materials, energy, time, human, etc. This course will expose engineers to the statistics to quantify and assess variability. In addition to statistical tools, we will delve deep into all phases of the DMAIC (Define, Measure, Analysis, Improve, and Control) methodology and the Lean/Six Sigma tools to identify, implement and document process improvements. An emphasis will be placed on the communication of these often-complicated statistics in an industrial setting. We will put these concepts into practice through completion of a final term paper. Students will be required to choose an industrial process and apply and communicate the concepts learned in this course.

MSE 610. Advanced Materials, Manufacturing and Applications Development. 3 Hours.
Introduction to advanced materials by design, near net-shape cost-effective manufacturing, synergistic knowledge of material properties, durability and function. Hands on activities related to extrusion-compression, fiber spinning, thermoset/thermoplastic materials, medical grade materials, intermediate forms and hybrid manufacturing. Integrated process and product development methodology. Student projects will involve manufacturing processes associated with mass production.

MSE 613. Mechanical Behavior of Materials. 3 Hours.
Microstructural effects on the deformation mechanisms responsible for mechanical behavior of engineering materials.

MSE 614. Process Quality Engineering. 3 Hours.
Application of the concepts and tools of total quality to develop, implement, and maintain an effective quality assurance system in a materials processing and manufacturing environment. Students will be exposed to probability models, statistical tools, linear and multiple regression, DOE, TQM and six sigma.

MSE 624. Physical Metallurgy. 3 Hours.
Course will consider the fundamental thermodynamic and kinetic principles governing the behavior of metals and alloys, particularly with respect to their influence the formation and evolution of microstructure. Topics will include liquid-solid and solid-state phase transformations, nucleation, growth, solidification and diffusion.

MSE 625. Plasma Processing of Materials. 3 Hours.
This course will introduce the concepts, fundamentals, and applications of plasma surface processing to materials science and engineering students. This course will feature a primer on plasmas as a unique thermodynamic state of matter. Specifically, there will be an emphasis on non-equilibrium thermal states and how these are used in materials processing and surface engineering. Special topics including plasma generation, control, and diagnostics will be provided. Furthermore, Types of Plasmas, CVD process for polymerization and hard coating, Corona treatment of fibers for composites, spark plasma sintering, plasma- spray coating, etc. surface characterization of plasma-processed surfaces will be discussed in detail: including structure/property relationships, surface morphology (including nanoscale features), and surface chemistry and their relationships to functional surface design. Spectroscopic techniques including x-ray photoelectron spectroscopy (XPS), optical emission spectroscopy (OES) and Surface mechanical properties testing (Nanoindentation) and contact angle measurements. Additional topics will be covered as time in the semester permits. This course will give prospective students a wide coverage of plasma tools and techniques toward functional material design.

MSE 628. Thermal Characterization. 3 Hours.
This lab-oriented course will be focused to give graduate students the theory and hands-on experience in operation, data acquisition and interpretation of widely used thermal characterization techniques such as differential scanning calorimeter (DSC), thermo gravimetric analyzer (TGA) , Simultaneous TGA-DTA, Thermo mechanical analyzer (TMA), Dynamic mechanic analyzer (DMA) and rheological and viscosity analyses of polymeric resins and composite materials. Exposure to TGA combination techniques with chemical analysis (Fourier Transform infrared spectrometer (FT-IR), Gas Chromatography (GC) and Mass spectrometry (MS)).

MSE 628L. Thermal Characterization Lab. 0 Hours.
Laboratory component of MSE 628 and must be taken concurrently.

MSE 629. Polymer Structure and Morphology. 3 Hours.
Polymer structures and morphology and it's relationships with applications, multicomponent polymer systems (polymer blends, copolymers, micro and nanocomposites), liquid crystalline polymers, polymer crystals, oriented polymers, morphological aspects of deformation and advances in polymers (biomimetic and bioinspired polymer systems).

MSE 633. Advanced Mechanics of Deformation. 3 Hours.
Basics and intermediate mechanics of deflection of beams and columns, mechanics of impact, failure theories, plastic deformation of materials, fracture mechanics, fatigue, creep and vibration. The topics will be supported by industry relevant case studies. Suggested prerequisites included Mechanics of Solids (CE 220) and Mechanical Behavior (MSE 382).

MSE 635. Advanced Mechanics of Composites. 3 Hours.
Classical lamination theory, analysis and failure of reinforced composite material systems, anisotropic elasticity, stress analysis and design of laminated composites including 3D effects, stress concentrations, free-edge effects, hygrothermal behavior, adhesive and mechanical connections.

MSE 636. Engineering Fibers. 3 Hours.
Processing-microstructure-properties of different fibrous materials: natural polymeric fibers (jute, sisal, silk, etc.), synthetic polymeric fibers (aramid and polyethylene, etc.), metallic fibers, and high performance ceramic fibers (alumina and silicon carbide). Application of Weibull statistics to strength of fibrous materials, techniques of mechanical testing of fibers and applications of fibers in various fields.

MSE 638. Degradation of Materials. 3 Hours.
Basics of materials degradation- thermodynamics and kinetics - Pourbaix diagram, chemical and electrochemical reactions; Degradation types and mechanisms; Degradation of different material systems: Metals, alloys, ceramics and glasses, polymers and composites for versatile applications- structural, functional, energy and biomedical; Impact on materials properties; Investigation for materials degradation; Protection from degradation and materials design; Environmental and biological aspects; Societal impact.

MSE 667. Process Modeling/Simulation. 3 Hours.
Theory and practice of analytical methods and computational modeling for manufacturing processes of metals, ceramics, polymers and composites. Applications on processes such as metal cutting, welding, casting, massive forming, solidification, rapid prototyping, injection molding and resin transfer molding.

MSE 668. Applied Finite Element Analysis. 3 Hours.
Finite Element Analysis (FEA) is used widely for design optimization and failure prediction in automobile, energy, aerospace, and other industries. This course primarily looks at how practically to set up static structural models and get meaningful results. The focus will be on applying loading and boundary conditions, good meshes, convergence of results, and correct interpretation of results. Students will learn how to set up models using programs such as Pro/Engineer and ANSYS.

MSE 670. Physical Characterization. 3 Hours.
Theory and practice of materials characterization, with emphasis on optical metallography, quantitative metallography, scanning electron microscopy, crystallography, and x-ray diffraction. Specific application in metals and ceramics considered.

MSE 670L. Physical Characterization Lab. 0 Hours.
Laboratory component of MSE 670 and must be taken concurrently.

MSE 690. Special Topics In (Area). 1-6 Hour.
Special Topics in (Area).

MSE 690L. Special Topics in (Area) Laboratory. 0 Hours.
Special Topics in (Area) laboratory.

MSE 691. Individual Study in (Area). 1-6 Hour.
Individual Study in (Area).

MSE 698. Non-Thesis Research. 1-12 Hour.

MSE 699. Thesis Research. 1-12 Hour.
Prerequisites: GAC M

MSE 702. Intro to Thermodynamics and Mechanics of Materials. 3 Hours.
This course is a survey of undergraduate level theory and application of the fundamental principles of mechanics of materials and thermodynamics. Understanding is based on the explanation of the physical behavior of materials under load and then modeling this behavior to develop the theory. Intended to provide the students with both the theory and application of the fundamental principles of thermodynamics of materials. Students must be graduate student in engineering, chemistry or physics.

MSE 703. Thermodynamics of Materials. 3 Hours.
Atomistic and classical approaches to the understanding of the thermodynamics of solids, phase transformations, chemical reactions, and alloy systems.

MSE 705. Introduction to Physical Materials. 3 Hours.
Overview of fundamental concepts of materials science and engineering, focusing on chemical and physical properties such as bonding, crystal structure and defects, diffusion, and phase diagrams.

MSE 710. Advanced Materials, Manufacturing and Applications Development. 3 Hours.
Introduction to advanced materials by design, near net-shape cost-effective manufacturing, synergistic knowledge of material properties, durability and function. Hands on activities related to extrusion-compression, fiber spinning, thermoset/thermoplastic materials, medical grade materials, intermediate forms and hybrid manufacturing. Integrated process and product development methodology. Student projects will involve manufacturing processes associated with mass production.

MSE 714. Process Quality Engineering. 3 Hours.
Application of the concepts and tools of total quality to develop, implement, and maintain an effective quality assurance system in a materials processing and manufacturing environment. Students will be exposed to probability models, statistical tools, linear and multiple regression, DOE, TQM and six sigma.

MSE 724. Physical Metallurgy. 3 Hours.
Course will consider the fundamental thermodynamic and kinetic principles governing the behavior of metals and alloys, particularly with respect to their influence the formation and evolution of microstructure. Topics will include liquid-solid and solid-state phase transformations, nucleation, growth, solidification and diffusion.

MSE 725. Plasma Processing of Materials. 3 Hours.
This course will introduce the concepts, fundamentals, and applications of plasma surface processing to materials science and engineering students. This course will feature a primer on plasmas as a unique thermodynamic state of matter. Specifically, there will be an emphasis on non-equilibrium thermal states and how these are used in materials processing and surface engineering. Special topics including plasma generation, control, and diagnostics will be provided. Furthermore, Types of Plasmas, CVD process for polymerization and hard coating, Corona treatment of fibers for composites, spark plasma sintering, plasma- spray coating, etc. surface characterization of plasma-processed surfaces will be discussed in detail: including structure/property relationships, surface morphology (including nanoscale features), and surface chemistry and their relationships to functional surface design. Spectroscopic techniques including x-ray photoelectron spectroscopy (XPS), optical emission spectroscopy (OES) and Surface mechanical properties testing (Nanoindentation) and contact angle measurements. Additional topics will be covered as time in the semester permits. This course will give prospective students a wide coverage of plasma tools and techniques toward functional material design.

MSE 728. Thermal Characterization. 3 Hours.
This lab-oriented course will be focused to give graduate students the theory and hands-on experience in operation, data acquisition and interpretation of widely used thermal characterization techniques such as differential scanning calorimeter (DSC), thermo gravimetric analyzer (TGA) , Simultaneous TGA-DTA, Thermo mechanical analyzer (TMA), Dynamic mechanic analyzer (DMA) and rheological and viscosity analyses of polymeric resins and composite materials. Exposure to TGA combination techniques with chemical analysis (Fourier Transform infrared spectrometer (FT-IR),Gas Chromatography (GC) and Mass spectrometry (MS)).

MSE 728L. Thermal Characterization Lab. 0 Hours.
Laboratory component of MSE 728 and must be taken concurrently.

MSE 729. Polymer Structure and Morphology. 3 Hours.
Polymer structures and morphology and it's relationships with applications, multicomponent polymer systems (polymer blends, copolymers, micro and nanocomposites), liquid crystalline polymers, polymer crystals, oriented polymers, morphological aspects of deformation and advances in polymers (biomimetic and bioinspired polymer systems).

MSE 733. Advanced Mechanics of Deformation. 3 Hours.
Basics and intermediate mechanics of deflection of beams and columns, mechanics of impact, failure theories, plastic deformation of materials, fracture mechanics, fatigue, creep and vibration. The topics will be supported by industry relevant case studies. Suggested prerequisites included Mechanics of Solids (CE 220) and Mechanical Behavior (MSE 382).

MSE 735. Advanced Mechanics of Composites. 3 Hours.
Classical lamination theory, analysis and failure of reinforced composite material systems, anisotropic elasticity, stress analysis and design of laminated composites including 3D effects, stress concentrations, free-edge effects, hygrothermal behavior, adhesive and mechanical connections.

MSE 736. Engineering Fibers. 3 Hours.
Processing-microstructure-properties of different fibrous materials: natural polymeric fibers (jute, sisal, silk, etc.) synthetic polymeric fibers (aramid and polyethylene, etc.), metallic fibers, and high performance ceramic fibers (alumina and silicon carbide). Application of Weibull statistics to strength of fibrous materials, techniques of mechanical testing of fibers and applications of fibers in various fields.

MSE 738. Degradation of Materials. 3 Hours.
Basics of materials degradation- thermodynamics and kinetics - Pourbaix diagram, chemical and electrochemical reactions; Degradation types and mechanisms; Degradation of different material systems: Metals, alloys, ceramics and glasses, polymers and composites for versatile applications- structural, functional, energy and biomedical; Impact on materials properties; Investigation for materials degradation; Protection from degradation and materials design;Environmental and biological aspects; Societal impact.

MSE 767. Process Modeling/Simulation. 3 Hours.
Theory and practice of analytical methods and computation modeling for manufacturing processes of metals, ceramics, polymers and composites. Applications on processes such as metal cutting, welding, casting, massive forming, solidification, rapid prototyping, injection molding, and resin transfer molding.

MSE 768. Applied Finite Element Analysis. 3 Hours.
Finite Element Analysis (FEA) is used widely for design optimization and failure prediction in automobile, energy, aerospace, and other industries. This course primarily looks at how practically to set up static structural models and get meaningful results. The focus will be on applying loading and boundary conditions, material properties, meshing, convergence, and correct interpretation of results. Students will learn how to set up models using programs such as Solidworks and ANSYS.

MSE 770. Physical Characterization. 3 Hours.
Theory and practice of materials characterization, with emphasis on optical metallography, quantitative metallography, scanning electron microscopy, crystallography, and x-ray diffraction. Specific application in metals and ceramics considered.

MSE 770L. Physical Characterization Lab. 0 Hours.
Laboratory component of MSE 770 and must be taken concurrently.

MSE 790. Special Topics in (Area). 1-6 Hour.
Special Topics In (Area).

MSE 790L. Special Topics in (Area) Laboratory. 0 Hours.
Special Topics in (Area) Laboratory.

MSE 791. Individual Study in (Area). 1-6 Hour.
Individual Study in (Area).

MSE 798. Non-Dissertation Research. 1-12 Hour.

MSE 799. Dissertation Research. 1-12 Hour.
Prerequisites: GAC Z

MSEM-Engineering Management Courses

MSEM 590. Special Topics in Engineering Management. 1-3 Hour.
Special Topics in Engineering Management.

MSEM 591. Individual Study in Engineering Management. 1-6 Hour.
Individual Study in Engineering Management.

MSEM 640. Systems Engineering. 3 Hours.
This course will explore systems engineering and systems thinking. Students will learn key topics related to engineering products and design, including requirements development, the project life cycle, system hierarchy, risk analysis, and cost analysis. They will learn that systems engineering is iterative and will develop judgment that will allow them to compare and evaluate engineering alternatives. They will learn to discuss systems engineering methods and processes as well as engage in systems thinking.

MSEM 650. Technical Project Management. 3 Hours.
Students will learn the common methodologies used to manage complex projects in technology organizations. They will learn how to successfully plan, schedule, budget, and complete projects. Topics will include the PMP, Six Sigma, Lean, and other methodologies. Students will take part in several class exercises that will allow them to use different project management skills. The format of the class will consist of lecture and general discussion. There will also be significant portions of class time dedicated to project based activities.

MSEM 660. Professional Development for Engineers. 3 Hours.
This course prepares students to make the transition from student to working engineer. Students will develop skills in personal branding, career planning, strategic career search, networking, teamwork, leadership, professional communications, time management, measuring value, and professional etiquette. In addition, students will learn how to find and develop opportunities and how to use social media to enhance and protect their personal brand.

MSEM 695. Engineering Management Design Project. 3 Hours.
This course is for students who already have a relevant job or internship and are part of the Master of Engineering Management program. The purpose of this course is to be a capstone program where the skills and concepts learned in the MSEM are applied to a real industry issue. This project will be performed in partnership with your current employer by defining a project on the job and working with MSEM faculty to meet core deliverables.

MSEM 696. Engineering Management Internship. 3 Hours.
This course is an internship and will be conducted in cooperation with an employer and the School of Engineering's Director of Career Services. Students will work with an industry partner and then provide a final report.