# ENGINEERING SCIENCE (ENGR)

**ENGR 130. Foundations of Engineering and Programming. 3 Units.**
Students will learn the fundamentals of engineering analysis and computer programming using a hands-on, project-based approach. During each module, students will collaborate to apply engineering skills, such as data analysis or prototyping, in addition to programming, to design a device. MATLAB will be the primary coding language. Projects incorporate skills from various engineering disciplines. In addition, students will learn about the engineering profession and the engineering design process. A laptop computer capable of running MATLAB is required for this course. Counts as a Quantitative Reasoning course.

**ENGR 131. Elementary Computer Programming. 3 Units.**
Students will learn the fundamentals of computer programming and algorithmic problem solving. Concepts are illustrated using a wide range of examples from engineering, science, and other disciplines. Students learn how to create, debug, and test computer programs, and how to develop algorithmic solution to problems and write programs that implement those solutions. Matlab is the primary programming language used in this course, but other languages may be introduced or used throughout. Counts as a CAS Quantitative Reasoning course. Counts as a Quantitative Reasoning course.

**ENGR 145. Chemistry of Materials. 4 Units.**
Application of fundamental chemistry principles to materials. Emphasis is on bonding and how this relates to the structure and properties in metals, ceramics, polymers and electronic materials. Application of chemistry principles to develop an understanding of how to synthesize materials. Prereq: CHEM 111 or equivalent.

**ENGR 200. Statics and Strength of Materials. 3 Units.**
An introduction to the analysis, behavior and design of mechanical/structural systems. Course topics include: concepts of equilibrium; geometric properties and distributed forces; stress, strain and mechanical properties of materials; and, linear elastic behavior of elements. Prereq: PHYS 121.

**ENGR 200S. Statics and Strength of Materials - Supplemental. 0 - 1 Units.**
This course allows students who are seeking transfer credit for ENGR 200 for a Statics course taken an another educational institution to obtain missing content in the area of Strength of Materials and to show passing proficiency in this content.

**ENGR 210. Introduction to Circuits and Instrumentation. 4 Units.**
Modeling and circuit analysis of analog and digital circuits. Fundamental concepts in circuit analysis: voltage and current sources, Kirchhoff's Laws, Thevenin, and Norton equivalent circuits, inductors capacitors, and transformers. Modeling sensors and amplifiers and measuring DC device characteristics. Characterization and measurement of time dependent waveforms. Transient behavior of circuits. Frequency dependent behavior of devices and amplifiers, frequency measurements. AC power and power measurements. Electronic devices as switches. Prereq: MATH 122. Prereq or Coreq: PHYS 122.

**ENGR 210S. Introduction to Circuits and Instrumentation - Supplemental. 1 - 3 Units.**
This course allows students who are seeking transfer credit for ENGR 210 for a Circuits course taken at another educational institution to obtain missing Laboratory content and to show passing proficiency in this content.

**ENGR 350. International Project Field Work. 1 Unit.**
Study abroad for design teams associated with the Center for Engineering Action (e.g. Humanitarian Design Corps, Engineers without Borders, senior design teams). Participation by instructor consent. Registration is limited to students who are active members of the project team. Participation in pre-trip preparation and post-trip assessment and documentation is required. A course fee will be assessed to contribute to travel and on-the-ground expenses. Counts as a Local & Global Engagement course.

**ENGR 350U. Global Health Design in Uganda. 3 Units.**
The CWRU Anthropology-Engineering Collaborative (AEC) offers this unique course applying social science and engineering skills and expertise to address global health issues in Uganda. The AEC is part of a longstanding collaboration between CWRU and Makerere University in Kampala, Uganda. Students collaborate with students at Makerere University in Kampala, Uganda and the CWRU student group, Global Health Design Collaborative (GHDC), to design and implement solutions to specific health issues in Luwero, Uganda. Students meet weekly during the semester to learn about global health technology design and anthropology. Students work with GHDC and program faculty on specific projects; activities may include conducting needs assessment, prototype development, design validation and verification, and preparation of a project report. Current projects focus on designing a pediatric pulse oximeter; identifying means to preserve the cold chain for vaccine outreach and improving medical waste disposal. In Uganda, students and their Makerere University counterparts travel together to Luwero district where they visit health centers to collaborate with local staff to review current design prototypes and issues. Activities include: talking to health center staff at different levels of the health care system, observing a community health outreach, and meeting with diverse stakeholders in Luwero and Kampala. Students gain hands-on experience in engineering design, social science methods, and working in transnational, interdisciplinary teams and contribute directly to ongoing efforts to address global health issues in Uganda. Students are encouraged to contribute to the projects through ongoing work with GHDC. The course may be taken as either ENGR 350U or ANTH 300. The course fee covers travel and on-the-ground expenses. The class is open to all majors but enrollment is by application and instructors' consent. Offered as ENGR 350U and ANTH 300. Counts as a CAS Global & Cultural Diversity course. Counts as a Local & Global Engagement course. Counts as a Understanding Global Perspectives course.

**ENGR 390. Basic Visual Communication. 2 Units.**
This course is focused on fundamental visual communication techniques for product development. Students will learn to explore and present their ideas through sketching, rendering, orthographic drawing and physical modeling. Drawing and modeling skills in this course will be practiced manually rather than digitally (i.e., pen and paper, hand-built models). Studio time will include group demos, in-class assignments and exercises, and one-on-one instruction. Coursework is tailored for Case students, however attempts will be made to align this course with the standard Industrial Design Communication Skills Course at The Cleveland Institute of Art (CIA). This will allow opportunities for networking and collaboration with CIA students. Prereq: Must be a Sophomore or above or in a declared Engineering major.

**ENGR 395. Community-engaged, Interdisciplinary Team-based Design Projects. 1 Unit.**
Community-engaged, interdisciplinary, team-based design projects under faculty guidance and with professional mentorship as appropriate. In order to enroll, a student must already be part of an approved project team. Teams will schedule weekly meetings together. Project activities will vary depending on the nature and status of the project, and may include needs finding and problem definition research, technical design, prototyping and testing, implementation and validation, etc. Engagement with a community partner (customer) is expected. Projects may be long term, possibly preceding and extending beyond the engagement time of individual students. Team members will have individual roles and responsibilities. The course is 1 credit, but may be repeated up to 3 credits. Students in all disciplines are welcome. Projects may involve international partnerships, but travel is not mandatory. Counts as a Local & Global Engagement course.

**ENGR 397. Interdisciplinary Solutions to Global Health Issues. 3 Units.**
This unique course brings together the expertise of engineers and social scientists to address global health issues through a combination of classroom-based learning and experiential learning through team-based design projects and field-based community assessments. Students will experience the process of engineering design by participating in teams organized around solutions to real-world health problems in the developing world. Methods from social sciences will be practiced and brought to bear in the process, including assessment of global health needs, and evaluation of success of interventions. Students will study and discuss current key issues in global health, and ethics surrounding health care, disparity, methods of intervention, and develop skills in how to define and frame problems and communicate effectively across disciplines. The course is organized around ongoing projects that seek to design technical solutions to global health issues, with a focus on Uganda. The teams will also work and learn with students and faculty of Biomedical Engineering and Social Sciences at Makerere University of Kampala (MUK), Uganda. Examples of interactions with MUK will include discussion of common readings, peer-review, and joint planning, implementation, and review of fieldwork. This course is an approved SAGES Departmental Seminar. A student in the Case School of Engineering may use this course to meet an Engineering Core Breadth requirement, either in place of ENGL 398 and ENGR 398, or as a Social Science course (ANTH 303 cross-list). No student may count the course to satisfy both of these requirements. Offered as ANTH 303 and ENGR 397. Counts as a CAS Global & Cultural Diversity course. Counts as a SAGES Departmental Seminar course. Prereq: Passing letter grade in a first year seminar in FSCC, FSSO, FSSY, FSNA, FSCS or FSTS.

**ENGR 398. Professional Communication for Engineers. 1 Unit.**
Students will attend lectures on global, economic, environmental, and societal issues in engineering, which will be the basis for class discussions, written assignments and oral presentations in ENGL 398. Recommended preparation: ENGL 150 or FSCC 100 or equivalent and concurrent enrollment in ENGL 398 (ENGL 398 and ENGR 398 together form an approved SAGES departmental seminar). Counts as a SAGES Departmental Seminar course. Prereq or Coreq: ENGL 398. Prereq: Prereq: 100 level first year seminar in FSCC, FSNA, FSSO, FSSY, FSTS, or FSCS.

**ENGR 399. Impact of Engineering on Society. 3 Units.**
As engineers, we design and implement technical solutions with the goal of improving people's lives, locally and globally. However, the technical solutions can have disparate impacts, in that they are beneficial to some people but less beneficial, or even detrimental, to others. What are our ethical and professional responsibilities to understand, consider, and perhaps address the disparate impacts of our work on the affected local and/or global populations? Counts as a Human Diversity & Commonality course. Counts as a Moral & Ethical Reasoning course. Counts as a Understanding Global Perspectives course.

**ENGR 400C. Graduate Cooperative Education. 0 Unit.**
An academic opportunity designed for graduate students to enhance their classroom, laboratory, and research learning through participation and experience in various organizational/industrial environments where theory is applied to practice. Graduate Cooperative Education experiences may be integrated with the student's thesis or research project areas, or be solely for the purpose of gaining professional experience related to the student's major field of study. Registration in this course will serve to maintain full-time student status for the period of time that the student is on a co-op assignment.

**ENGR 401C. Graduate Cooperative Education. 0 Unit.**
An academic opportunity designed for graduate students to enhance their classroom, laboratory, and research learning through participation and experience in various organizational/industrial environments where theory is applied to practice. Graduate Cooperative Education experiences may be integrated with the student's thesis or research project areas, or be solely for the purpose of gaining professional experience related to the student's major field of study. Registration in this course will serve to maintain full-time student status for the period of time that the student is on a co-op assignment. Prereq: ENGR 400C.

**ENGR 410C. Graduate Cooperative Education Part-time. 0 Unit.**
An academic opportunity designed for graduate students to enhance their classroom, laboratory, and research learning through participation and experience in various organizational/industrial environments where theory is applied to practice. Graduate Cooperative Education experiences may be integrated with the student's thesis or research project areas, or be solely for the purpose of gaining professional experience related to the student's major field of study. This is a 0 credit course that allows students to enroll in the co-op program while working up to 20 hours per week. Students must be enrolled as a full-time student to be eligible for this course. Proof of full-time enrollment is required.

**ENGR 420A. Introduction to Advanced Statistics in Healthcare. 2 Units.**
Healthcare has been disrupted by the entry of new technologies in the digital Age. Particularly with the advent and increased adoption of of automation, machine learning and artificial intelligence (AI), doctors, hospitals, insurance companies, and industries with ties to healthcare have all been impacted. This course will discuss various challenges and potential areas of automation, exposure to medical ethics including the Declaration of Helsinki. Students will learn different experimental techniques for collection of epidemiological and normative data, understand the difference between incidence and prevalence of a disease, between association and causation, and between validity and reliability of measuring techniques. Use of advanced statistics in hospital management and medical research will be covered. This course will cover use cases that require aspects like compiling and analyzing information (like electronic medical records, the international classification of diseases (ICD-10), etc), develop AI programs to collect, store, re-format, and trace data to provide faster, more consistent access. Additionally, the use of advanced statistical and AI techniques in Healthcare will be demonstrated via use cases such as analyzing tests, X-Rays, CT scans, data entry, and other mundane tasks that can potentially reduce the operational cost. Prereq: ENGR 420B and ENGR 420F.

**ENGR 420B. Introduction to Applied Statistics for Decision Support in Data Science. 3 Units.**
Statistics and Probability are tools that can be used to get insights from data and thereby solutions to engineering and business problems. It is mostly assumed that beginners who are learning Machine Learning have some background in statistics and this course will provide the required skills. Descriptive Statistics are used to transform raw data into information and inferential statistics are used to analyze the whole data from samples of data. These form the prerequisite to the field of applied machine learning. Recommended preparation: familiarity with calculus and linear algebra at the higher secondary level.

**ENGR 420C. Artificial Intelligence: Sequential Decision Making. 2 Units.**
This introduces advanced AI models in the areas of computer vision and natural language processing as well as reinforcement learning techniques along with their implementation for industrial applications. The primary focus is on deep learning based modeling with a brief introduction to traditional computer vision and NLP techniques. The course begins with introduction to 'tensorflow' a scalable and deployable programming platform for building neural network architectures. The first theory lecture introduces to the world of computer vision along with traditional approaches and a comparison is drawn between traditional methods and DL for computer vision. In the following lectures multiple advanced neural network architectures are taught along with their application usecases (visual inspection, medical imaging, object detection, OCR, Face recognition, video analysis, etc.). Computer vision is followed by introduction to NLP and traditional techniques like HMMs and CRFs followed by DL architectures for sequence (text, video, audio, speech etc.) modeling. Different application usecases (NER, language modeling, speech recognition, etc.) along along with required theory are presented. Introduction to reinforcement learning and its combination with deep learning is presented towards the end of the course. During the labs all steps of building an application, from the training of the model to its deployment, are discussed. How to combine traditional methods with DL and possible usecases are also discussed. The objective of the course is to make the participants familiar with the state-of-the-art DL and RL techniques for real world problems along with the knowledge to implement solution pipelines. The participants are expected to have very good knowledge of programming platforms like Python (or others) and they must be familiar with machine learning, basic DL techniques (MLP, CNN, RNN and LSTM). Prereq: ENGR 420B, ENGR 420E, and ENGR 420F.

**ENGR 420D. Introduction to Contemporary Issues in Data Mining and Big Data. 3 Units.**
Eighty percent of the data available in the world since the dawn of Humanity has been generated in the last five years and it is not just structured but there is a variety to it (like, text, images, audio, video, etc.). Vast amount of data is being collected in medical and social research and in many industries. Such big data generates a demand for efficient and practical tools to analyze the data and to identify unknown patterns. This has created a lot of issues in building effective Data Mining and Data Science solutions. Hadoop technology platform deals with massive volumes/varieties and fast-growing data have come up in recent years to deal with such contemporary issues. Apache Spark, the unified analytics engine, has seen rapid adoption by enterprises across a wide range of industries. Data scientists, analysts, and general business intelligence users rely on interactive SQL queries for exploring data, deal with streams of data, build Machine Learning models to use the predictive power and draw business insights. This course will help students handle such issues in data science through use of Big data techniques and tools. Prereq: ENGR 420B, ENGR 420E, and ENGR 420F.

**ENGR 420E. Introduction to Data Mining and Visualization Techniques. 3 Units.**
Industry today is looking for someone who can develop data science solutions using open source tools and technologies. The languages such as "R" and "Python" play a significant role facilitating the building of statistical and data science models and approaches to visualize data and making predictions to support decisions. The languages are taught from basics such as objects, data types, functions, control structures, etc., that are essential to read and manipulate a lot of structured data. Some of the basic skills like data acquisition, analysis, dealing with inconsistencies within the data and cleansing, transforming the data as required for further modeling and several other traits to prepare the data will be taught. It is also a common practice to begin the data analysis by visualizing the data in addition to computing summary descriptive statistics. Well-designed visualization techniques can decrease cognitive workload, provide simpler perceptual inferences and improve comprehension of large sets of data to facilitate decision making. Techniques and algorithms for creating effective visualizations will be covered along with the required basics of R, Python and Tableau to generate descriptive statistics, run experiments and draw inferences, visualize the data and present a data story.

**ENGR 420F. Introduction to Methods and Algorithms for Machine Learning. 3 Units.**
Traditional statistical methods and Machine learning methods coexist, and it is essential for every Data Science enthusiast to learn both and exploit them as they deem fit. Machine Learning is an algorithm that can learn from data without relying on rules-based programming. In this course a variety of machine learning techniques (supervised learning and unsupervised learning), with data examples from biomedical and social research will be covered. Specifically, prediction model building and model-based feature selections, classification (tree-based methods, bagging, random forests, boosting, support vector machines, association rules, clustering and hierarchical clustering, k-nearest neighbors will be covered. Industry case studies will be used to provide students an overview of how a data science project is executed and help them learn all the components of the data science pipeline, and to carry out descriptive, predictive and prescriptive analytics. For a given use case, we teach how to choose between a variety of tools and techniques that suit the problem statement and at every stage how to validate the choice and tune the model performance. When it comes to solving real-world problems for any industry it is equally important to know how to work with all the stakeholders in the organization and build plugins that the business can use. Some of the important aspects like architecting a solution, production deployment and how to deal with challenges and some best practices will be covered. Additionally, this course is designed to broaden the learning horizons and introduce students to unstructured data (Natural Language and computer vision). Some of the state-of-the-art tools and techniques to build supervised and unsupervised approaches to build systems that can-do intelligent things will be introduced. It includes ANN, Deep learning, Convolution nets, RNN and LSTMs. The course goes into details of architecture, implementation and mathematical background of SOTA NLP and computer vision techniques and then build several interesting applications. This program provides a good overview of how learned techniques can be used to build interesting commercial applications in healthcare, medicine, biometrics, speech, OCR, etc. We also dive deep into the engineering aspects and enable participants to think of possibilities in other domains as well. Additionally, another branch of mathematical models, namely Optimization techniques will be covered to build intelligent systems. Recommended preparation: ENGR 420B or concepts covered in that class.

**ENGR 600. M.S. Engineering Culminating Experience. 0 Unit.**
Culminating experience for MS course focused track in engineering. Prereq: M.S. student in Engineering - course focused track.