MSEE Curriculum

All MSEE students are required to take the following two core courses:

- 3531-571 Linear systems
- 3531-507 Probability and Random Processes

The course requirements for students majoring in the Communications and Signal Processing area are:

i) Take the following two core courses
   - 3531-458/558 Digital Signal Processing I
   - 3531-469/569 Digital Communications

ii) Select the rest of the courses from Groups A and C of suggested and free elective courses. Selected courses must be approved by the student's advisory committee.
iii) Project option students must take 3531-599 Master's Project that counts for 3 credit hours.
iv) Thesis option students must take 3531-699 Master's Thesis that counts for 6 credit hours.

The course requirements for students majoring in the Digital Systems Engineering area are:

i) Take the following two core courses
   - 3531-559 Computer Architecture
   - 3531-584 Digital System-level Design

i) Select the rest of the courses from Groups A and C of suggested and free elective courses. Selected courses must be approved by the student's advisory committee.
ii) Project option students must take 3531-599 Master's Project that counts for 3 credit hours.
iii) Thesis option students must take 3531-699 Master's Thesis that counts for 6 credit hours.

<u>Group A list of Suggested Elective Courses</u>

- 3531-455/555 Adaptive Filters
- 3531-460/560 Digital Image Processing
- 3531-468/568 Wireless Communications
- 3531-469/569 Digital Communications I
- 3531-478/578 Digital Integrated Circuit Design
- 3531-479/579 Digital Integrated Circuit Design Laboratory
- 3531-480/580 Introduction to Computer-Aided Digital Design
- 3531-483/583 Introduction to Computer Aided Digital Design Lab
- 3531-559 Computer Architecture
- 3531-574 Digital Information Theory
- 3531-575 Wireless Networks
- 3531-584 Digital System-level Design
- 3531-585 Design of a System on a Chip (SoC)

- 3531-586 Advanced Embedded System design
- 3531-658 Digital Signal Processing II
- 3531-659 Advanced Computer Architecture
- 3531-665 Multimedia Communications
- 3531-669 Digital Communications II
- 3531-673 Coding Theory and Applications
- 3531-678 Advanced Digital Integrated Circuit Design
- 3531-692 Advanced Topics in Signal and Image Processing
- 3531-693 Advanced Topics in Digital Communications
- 3531-599 Master's Project (3 credit hours)
- 3531-699 Master's Thesis (6 credit hours)

Group B list of Suggested Elective Courses

- 3531-455/555 Adaptive Filters
- 3531-458/558 Digital Signal Processing I
- 3531-460/560 Digital Image Processing
- 3531-468/568 Wireless Communications
- 3531-469/569 Digital Communications
- 3531-478/578 Digital Integrated Circuit Design
- 3531-479/579 Digital Integrated Circuit Design Laboratory
- 3531-480/580 Introduction to Computer-Aided Digital Design
- 3531-483/583 Introduction to Computer Aided Digital Design Lab
- 3531-574 Digital Information Theory
- 3531-575 Wireless Networks
- 3531-585 Design of a System on a Chip (SoC)
- 3531-586 Advanced Embedded System design
- 3531-592 Advanced Topics in Signal and Image Processing
- 3531-658 Digital Signal Processing II
- 3531-659 Advanced Computer Architecture
- 3531-665 Multimedia Communications
- 3531-669 Digital Communications
- 3531-673 Coding Theory and Applications
- 3531-678 Advanced Digital Integrated Circuit Design
- 3531-693 Advanced Topics in Digital Communications
- 3531-599 Master's Project (3 credit hours)
- 3531-699 Master's Thesis (6 credit hours)

Group C (Free Electives)

Courses in computer science, mathematics, or any other related courses that the student's advisory committee approves. Selected courses must logically fit within the student's plan of study.

Detailed Catalog Descriptions for Courses in the Program

3531-455/555 Adaptive Filters

The theory and design techniques of finite-impulse response filters. Stationary discrete-time stochastic processes, Wiener filter theory, the method of steepest descent, adaptive transverse filters using gradient-vector estimation, analysis of the LMS and RLS algorithm. Adaptive filters design and software/hardware implementations. Application examples in noise canceling, channel equalization, and array processing. Students enrolled in the 500-level course will be required to complete additional work as stated in the syllabus. Lec. 3 hrs., Prerequisite: 3531-458/558, Graduate standing or consent of instructor.

3531-458/558 Digital Signal Processing I

Time and frequency analysis of discrete- time signals and systems. Fast implementations of the DFT and its relatives. IIR and FIR digital filter design, implementation, and quantization error analysis. Decimation, interpolation and introduction to multirate digital signal processing. Students enrolled in the 500-level course will be required to complete additional work as stated in the syllabus. Lec. 3 hrs., Prerequisite: 3531-371 or consent of instructor.

3531-460/560 Digital Image Processing

Fundamental principles and algorithms for digital image processing. Two-dimensional spatial frequency transforms. Image enhancement, histogram equalization, smoothing and sharpening. Image encoding, analysis, and segmentation. Feature extraction, and object and pattern recognition. Students enrolled in the 500-level course will be required to complete additional work as stated in the syllabus. Lec. 3 hrs., Prerequisite: 3531-458/558 or consent of instructor.

3531-468/568 Wireless Communications

Cellular radio concepts: frequency reuse and handoff strategies. Large scale path loss models; fading and multipath: flat fading versus frequency selective fading; modulation schemes for mobile communication: narrowband versus spread spectrum; equalization; RAKE receiver; multiple access techniques; FDMA, CDMA; and co-channel interference and channel capacity. Common wireless standards. Students enrolled in the 500-level course will be required to complete additional work as stated in the syllabus. Lec. 3 hrs., Prerequisite.: 3531-307 and 3531-371, graduate standing or consent of instructor.

3531-469/569 Digital Communications I

Basis functions, orthogonalization of signals, vector representation of signals, optimal detection in noise, matched filters, pulse shaping, intersymbol interference, maximum likelihood detection, channel cutoff rates, error probabilities, bandwidth, and power-limited signaling. Students enrolled in the 500-level course will be required to complete additional work as stated in the syllabus. Lec. 3 hrs., Prerequisite: 3531-467, graduate standing or consent of instructor.

3531-478/578 Digital Integrated Circuit Design Lecture

Studies the design process of VLSI CMOS circuits. Also covers all the major steps of the design process, including logic, circuit, and layout design. A variety of computer-aided tools are discussed and used to provide VLSI design experience that includes design of basic VLSI CMOS

functional blocks, and verification of the design, testing, and debugging procedures. Students enrolled in the 500-level course will be required to complete additional work as stated in the syllabus. Lec. 3 hrs., Prerequisite: 3531 312, 352. Co-requisite: 3531-479.

3531-479/579 Digital Integrated Circuit Design Laboratory

Provides VLSI design experience that includes design of basic VLSI CMOS functional blocks, verification of the design, testing, and debugging. Several complex VLSI projects will be submitted for fabrication. Students enrolled in the 500-level course will be required to complete additional work as stated in the syllabus. Lab. 1 hrs., Co-requisite: 3531-478/578.

3531-480/580 Introduction to Computer-Aided Digital Design

Introduces the techniques of modeling digital systems at various levels of abstraction and computer-aided design algorithms applied to these models to support design and analysis tasks. Covers modeling through the use of a modern hardware description language (VHDL/Verilog), test generation, event-driven simulation algorithms, and physical design used to map the synthesized logic design onto physical IC area. This is not a how-to course on using CAD tools; it is a study of the algorithms used by CAD tools. Students enrolled in the 500-level course will be required to complete additional work as stated in the syllabus. Prerequisite: 3531-312, graduate standing or consent of instructor.

3531-483/583 Introduction to Computer Aided Digital Design Lab

The course emphasizes the use of computer-aided design (CAD) tools in the description, modeling, simulation, verification and testing of digital systems. Alternative coding styles and methodology used for combinational and sequential digital logic designs are evaluated. The use of Field Programmable gate arrays is integrated into the course as the target physical domain. Students enrolled in the 500-level course will be required to complete additional work as stated in the syllabus. Lab 3 hrs., Prerequisite: 3531-312, Co-requisite: 3531-480, graduate standing or consent of instructor.

3531-507 Probability and Random Processes

Foundations for the engineering analysis of random processes: Review of probability theory, Introduction to stochastic processes, Continuous time and discrete time processes, Mean functions, correlation functions, covariance functions, noise, Strict- and wide-sense stationarity, ergodicity, Gaussian processes, power spectral densities, mean square estimation, Markov processes. Prerequisite: Graduate standing and understanding of probability at the level of 3531-307 or consent of instructor.

3531-559 Computer Architecture

Advanced computer architectures with emphasis on multiprocessor systems and the principles of their design and cost/performance factors. Instruction set design and implementation, RISC vs. CISC instruction sets; datapath and controller design, pipeline design; fixed and floating-point arithmetic; memory hierarchy designs, caches, memory systems; I/O systems and their interconnect. Interrupt and exception. Prerequisite: 3531-459, graduate standing or consent of instructor.

3531-571 Linear systems

Methods of linear-system analysis, in both time and frequency domains, are studied. Techniques used in the study of continuous and discrete systems include state-variable representation, matrices, Fourier transforms, LaPlace transforms, inversion theorems, sampling theory, discrete and fast Fourier transforms, and Z-transforms. Computer simulation, analysis, and design software packages are used. Graduate standing and understanding of Signal & Systems at the level of 3531-371 or consent of instructor.

3531-574 Digital Information Theory

Entropy and mutual information, Huffman coding, Shannon's source coding theorem, channel coding theorems, channel capacity, block coding error bounds, random coding bounds, cutoff rate, multi-user information theory, random access channels and protocols, multi-access coding methods. Lec. 3 hrs., Prerequisite: 3531-458/558, graduate standing or consent of instructor.

3531-575 Wireless Networks

Fundamental concepts of wireless networks: network architecture for personal communications systems, wireless LANs, radio, tactical and other wireless networks, and design and analysis of protocols on a regular basis. Lec. 3 hrs., Prerequisite: 3531-468/568, graduate standing or consent of instructor.

3531-584 Digital System-level Design

Digital system designs for Digital System Processors and Communications systems: Applications include matched filters, FFT, QAM Modulators, Raised Cosine Filter, Reed-Solomon and hamming code decoders, error detection and correction circuits, demodulation, and soft and hard decision decoders. Extensive use of hardware and software system-level design tools and packages. Prerequisite: 3531-480/580, graduate standing and understanding of computer organization at the level of 3531-459 or consent of instructor.

3531-585 Design of a System on a Chip (SoC)

System-level design and optimization of multiprocessor systems on a reconfigurable chip. System-level design methodologies. System level design representations and modeling languages. System level modeling. System specification, algorithm modeling, decomposition, IP selection. Synthesis and co-verification of system components. Extensive use of state-of-the-art of CAD tools and FPGA boards. Lab 3 hrs., Prereq: 3531-480/580, graduate standing or consent of instructor.

3531-586 Advanced Embedded System design

Advanced embedded system design principles and practices. Emphasizes formal design methodologies such as hardware-software co-design and co-verification, performance optimization, distributed embedded systems. Soft core and hard core embedded microprocessors. Prerequisite: 3531-480/580, graduate standing or consent of instructor.

3531-658 Digital Signal Processing II

Overview of z-transform, FFT, llR and FIR filters. Multirate digital signal processing. Optimum filtering of noisy signals. Adaptive digital filters. Power spectrum estimation. Wavelet transform. Interference canceling. Selected applications of DSP techniques in speech, communications and image processing. Lec. 3 hrs., Prerequisite 3531-458/558, graduate standing or consent of instructor.

3531-659 Advanced Computer Architecture

High performance computer architectures: instruction set principles, pipelining, multiprocessing systems, parallel processing, instruction level parallelism, fine-grain and coarse grain parallelism, SIMD, MIMD, multiple instruction issue, data coherency, memory hierarchy design, interconnection networks, vector processors. Prerequisite: 3531-559, graduate standing or consent of instructor.

3531-665 Multimedia Communications

Comprehensive coverage of media compression, synthesis and recognition, media communications and networking, and standards for audiovisual communications over wired and wireless networks. Lec. 3 hrs., Prerequisite: 3531-469/569, graduate standing or consent of instructor.

3531-669 Digital Communications II

The theory and practice of efficient digital modulations over linear dispersive channels, including adaptive equalization and synchronization. Lec. 3 hrs., Prerequisite: 3531-469/569, graduate standing or consent of instructor.

3531-673 Coding Theory and Applications

The theory and practice of error control coding with emphasis on linear, cyclic, convolutional, and parallel concatenated codes (Hamming codes, Repetition codes, polynomial codes, Reed Solomon Codes). Turbo codes, Viterbi decoding and applications. Lec. 3 hrs., Prerequisite: 3531-469/569, graduate standing or consent of instructor.

3531-678 Advanced Digital Integrated Circuit Design Lecture

Design and implementation of very-large-scale-integrated systems (VLSI) with emphasis on full-custom chip design. Topics will include device and interconnect modeling, static and dynamic logic families, latch and flop design, RAM design, ALU design, low power techniques, power supply and clock distribution, signal integrity, and I/O design. Extensive use of CAD tools for IC design, simulation, and layout verification. Lec. 3 hrs., Prerequisite: 3531-478/578 and 3531-478/578, graduate standing or consent of instructor.

3531-692 Advanced Topics in Signal and Image Processing

Topics of current interest in signal and image processing. Content may vary from offering to offering. Lec. 3 hrs., Prerequisite: Graduate Standing or consent of instructor.

3531-693 Advanced Topics in Digital Communications

Topics of current interest in digital communications. Content may vary from offering to offering. Lec. 3 hrs., Prerequisite: Graduate Standing or consent of instructor.

3531-599 Master's Project. Lab 3 hrs, Prerequisite: Graduate Standing or consent of instructor.

3531-699 Master's Thesis. Lab 6 hrs, Prerequisite: Graduate Standing or consent of instructor