ENGINEERING & COMPUTER SCIENCE

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Academic Programs	Credits
BS: Computing	40
Computer Science Emphasis	
Software Systems Emphasis	
Minor in Computing	20
BS in Engineering	
Electrical and Computer Engineering Emphasis	66
Mechanical Engineering Emphasis	66
Minor in Engineering	20
MS: Software Engineering	32
MSA: Engineering Management	
See the School of Business Administration	

Undergraduate Programs

Computing

Two emphases are available in Computing—**Computer Science** and **Software Systems**.

Computer Science focuses on a study of computing as well as on its role in an application area. Areas of interest include artificial intelligence, compilers, computer architectures, computer graphics, computer networks, operating systems, program development, and analytical theory. A degree in computing with the Computer Science emphasis prepares students for graduate study, employment in computer systems/ networks, administration/ development, software development/ maintenance, and for careers in education.

Software Systems is an applied study of computing, focusing on the development and maintenance of software in an application area. A minor in an application area is included as part of the degree. Typical minors might include one of the sciences, behavioral science, or business. Supervised "real-world" projects are a requirement for this degree. A degree in Computing with the Software Systems emphasis prepares students for employment in developing and maintaining commercial applications and for graduate studies in applied computing such as software engineering.

BS in Computing

Major requirements—40
Common core—19
CPTR151, 152, 276, 440, 460, 466

Computer Science Emphasis

Required courses—9
CPTR425, 437, 467
Major electives—12
Chosen from CPTR courses in consultation with an advisor.
A minimum of 12 upper division credits required.
Cognate requirements—26–28
MATH141, 142, 355; STAT340 (14)
ENGR385 (4)
BIOL165; 166 (10)*
or CHEM131, 132 (8)*
or PHYS141, 142 (8)*
or PHYS241, 242, 271, 272 (10)*
* These courses may apply toward the general education natural science requirement

Software Systems Emphasis

Required courses—9
CPTR310, 427, 450
Major electives—12
Chosen from CPTR courses in consultation with an advisor.
A minimum of 12 upper division credits required.
Cognate requirements—29–31
MATH182, 355; STAT285 (9)
Minor in an advisor-approved application area (20-22)

Minor in Computing (20)

Required courses—12
CPTR125, 151, 152, 276
Minor electives—8
Chosen from CPTR courses in consultation with an advisor.
Notes:
No course grade below a C- may apply to a major or minor in Computing.

A minimum GPA of 2.25 may apply to a major or minor in Computing.

A secondary-education endorsement is available for students seeking either a major or minor in Computing. In such cases, CPTR459 must be taken. Consult the School of Education for further information.

Engineering

The engineering program at Andrews University leads to a Bachelor of Science in Engineering degree with emphases in Electrical and Computer Engineering and in Mechanical Engineering. These two emphases build on a strong traditional mathematics, science, and engineering core. The Electrical and Computer Engineering emphasis focuses on the areas of digital systems, communication systems, and computer controlled instrumentation and computer simulation. The Mechanical Engineering emphasis focuses on mechanical design and the electromechanical elements of smart machines.

The mathematics courses listed as cognates for the engineering degree satisfy the requirements for a minor in mathematics. A second major in mathematics requires 6 additional credits in mathematics, and a second major in physics requires 14–17 additional credits in physics. See the Mathematics and Physics department listings for details.

BS in Engineering

Major requirements—66
Common core—30
ENGR120, 125, 180, 185, 225, 275, 285, 310, 450, 491, 492
Cognates—35
MATH141, 142, 215, 240, 286; STAT340
CHEM131, PHYS241, 242, 271, 272

Electrical and Computer Engineering Emphasis

Required courses—31
CPTR151, 152, 465, ENGR325, 335, 385, 415, 435, and 455.
Major electives—5
Chosen from upper division ENGR and CPTR courses in consultation with an advisor.

Mechanical Engineering Emphasis

Required courses—30
CPTR125, ENGR320, 330, 340, 350, 360, 390, 410, 420, and 440.
Major electives—6
Chosen from upper division ENGR courses in consultation with an advisor.

Minor in Engineering (20)

Required courses—10
ENGR120, 125, 185, 225
Minor Electives—10
Chosen from ENGR courses in consultation with an engineering advisor.
Cognates: MATH182 or MATH141, 142

Graduate Programs

MS: Software Engineering

Software Engineering is an applied study of computing focusing on the software development process through the application and synthesis of principles from computer science and related fields. Emphasis is placed on practical results balanced by scientific foundation. Supervised "real-world" projects are a requirement for this degree.

Admission requirements. In addition to meeting the general graduate admission requirements on pp. 47–51 of the bulletin, students applying for admission to the MS: Software Engineering program must show evidence that they have taken academic course work and/or demonstrate proficiency in the following areas:

Calculus
Computer Organization and Assembler
Discrete Mathematics
Elementary Data Structures
Probability or Statistics
Programming proficiency in two computer languages (including C or C++)

Degree requirements—34
A minimum of 34 semester credits. At least 22 credits chosen from 500- and 600-level graduate courses. The Comprehensive Examination must be successfully completed prior to graduation. Completion of the following requirements:

Foundation—0–9
CPTR427, 440 and 460 are required unless previously taken at the undergraduate level.
Core courses—10
CPTR560, 561, 562, 637
Thesis—6
A thesis option must involve software development.
Electives—9–18
Complete any acceptable 400-600 level CPTR courses chosen in consultation with an advisor.

MSA: Engineering Management Emphasis

See graduate programs for the School of Business Administration.

Courses (Credits)

See inside front cover for symbol code.

Computing and Software Engineering

CPTR125 **$ (3)**
Introduction to Computer Programming
Programming in a selected language. May be repeated for a total of three unique languages. Satisfies general education requirements for computing majors. Only 3 credits of CPTR125 may apply toward a computing major or minor. *Fall, Spring*

CPTR151 **$ (4)**
Computer Science I
An introduction to programming methodology using C++, UNIX usage, problem-solving, algorithm development, control structures, arrays, program style, design correctness and documentation techniques, as well as a brief overview of computer systems and computer history. *Fall*

CPTR152 **$ (3)**
Computer Science II
A continuation of CPTR151 examines program specifications, design, coding, correctness, and style with additional coverage of pointers and arrays, and an in-depth study of recursion and data structures. Includes files, lists, stacks, queues, trees, graphs, and an overview of computer ethics. Prerequisite: CPTR151. *Spring*

CPTR276 **$ (3)**
Data Structures and Algorithms
A study of techniques for the design and analysis of algorithms using appropriate data structures covered in CPTR152. Topics include: asymptotic complexity bounds, graph and tree algorithms, fundamental algorithmic strategies (such as greedy, divide-and-conquer, backtracking, branch-and-bound, heuristics, pattern matching and string/text algorithms), numerical approximation and dynamic programming. Prerequisite: CPTR152. *Fall*

CPTR295 **(1–3)**
Directed Computer Language Study
Directed study of computer language in consultation with the instructor. Normally, the language is not included in other courses taught by the department. A programming project may be required. Prerequisites: CPTR151 or equivalent.

CPTR310 **♦ Alt (3)**
Database Application Programming
A study of basic database principles and web applications using technologies such as PHP, MySQL, Three Tier Architectures, scripting languages and data manipulation. Manipulating database using SQL. Sessions, authentication and security. Prerequisite: CPTR151. *Spring* (odd years)

CPTR416 **♦ $ Alt (3)**
Internet Technologies
A study of current technologies and their effects, including web server software, e-commerce, various scripting languages, human-computer interaction, perception, and related issues. Prerequisite: CPTR152. *Fall* (even years)

CPTR425 **♦ $ Alt (3)**
Programming Languages
Survey of current programming languages, including structure, runtime systems, the specification of syntax, and semantics. Definition of syntax for formal languages with emphasis on context-free languages. Techniques for scanning and parsing programming languages. Automated grammar analysis parsers. Prerequisite: CPTR276. *Fall* (even years)

CPTR427 **♦ $ Alt (3)**
Object-Oriented Design and Programming
Emphasizes the study of object-oriented analysis and design methodologies and the application of these to the development of advanced software. Includes survey of object-oriented programming languages and environments. Prerequisite: CPTR152. *Fall* (odd years)

CPTR436 **♦ $ Alt (3)**
Numerical Methods and Analysis
A study of common numerical techniques applicable on a computer. Includes interpolation, extrapolation, approximation techniques, numerical methods for linear problems, root finding, function fitting, numerical integration, location of extremes, efficiency of numerical algorithms, and minimization of computational error. Prerequisites: CPTR276 and MATH215. *Fall* (even years)

CPTR437 **♦ $ Alt (3)**
Formal Theory of Computation
Includes post productions, Turing machines, and recursive functions. Recursive and recursively enumerable sets. Undecidability results of computation. Prerequisites: CPTR152 and MATH355. *Fall* (odd years)

CPTR440 **♦ $ Alt (3)**
Operating Systems
Process management, including asynchronous concurrent processes and deadlock. Virtual storage management and job and process scheduling. Multiprocessing. Disk scheduling and file and database systems. Performance and security. Prerequisite: CPTR276. *Spring* (odd years)

CPTR450 **♦ Alt (3)**
Network Computing and Architecture
Concepts applicable to constructing a computer network and the application of computing algorithms and solutions using networked computers and devices. Study topics such as physical transmission media, protocols and associated layers, TCP/IP, application programming interfaces and frameworks, sockets, clustering and security. Prerequisite: CPTR152. *Fall* (even years)

CPTR459 **Alt (2)**
Secondary Methods: Computer Science
Considers computer science programs in the secondary school and presents information and materials for teaching computer science in secondary school. Topics include organization and maintenance of equipment, publications, legal issues, dealing with diversity of abilities, problem-solving skills, and strategies for debugging programs. Prerequisite: CPTR276.

CPTR460 **♦ $ (3)**
Software Engineering
Surveys basic software engineering topics associated with the processes, documents, and products of the entire software life cycle. Topics include software evolution, project organization, and management, feasibility studies, product definition, design, implementation, and testing issues, and the role of the software engineer within the life cycle. Prerequisite: CPTR152. *Fall*

CPTR465 **♦ Alt (3)**
Computer Architecture
Focus on hardware aspects of computing and logical concepts. Includes data representation for numbers and other data types, Boolean algebra, digital logic circuit representations of basic computational building blocks, CPU components, interrupt schemes and buses. Relevance of supporting concepts is discussed, including system software, assemblers, assembly language programming and operating systems. Prerequisite: CPTR152. *Fall* (odd years)

CPTR466 **(2)**
Software Engineering Group Project
The implementation of a group project and the study of topics related to the group project, including CASE tools, 4GL's, and graphical user interfaces. Emphasizes written documents and oral presentations associated with group project rather than lecture. Corerequisite: CPTR460. *Fall*

CPTR467 **♦ Alt (3)**
Database Concepts and Theory
Study of issues relevant to abstract and concrete aspects in both the creation of database management system software and its use. Indexing, buffering and other internal and physical database design issues. Relational model algebra, calculus and query languages (including SQL). Functional dependencies and normalization. Study of and modeling using Entity-Relationship and other relevant paradigms. Common application databases. Introduction to the use of transactions, query optimization and non-relational database models. Design and programming assignments using databases. Prerequisite: CPTR152. *Spring* (even years)

CPTR475 **(1–4)**
Topics in _____
Selected topics of current interest in computer science such as Robotics, advanced languages, or others. Repeatable with different subjects.

CPTR485 **♦ $ Alt (3)**
Computer Graphics
Introduction to computer graphics focusing on the algorithms and data structures for the modeling and shading of 3-d images. Topics include basic OpenGL programming, mesh generation, shading, raytracing, radiosity methods, procedural textures, and fractal methods. Prerequisites: CPTR 152. *Fall* (odd years)

CPTR487 **♦ $ Alt (3)**
Artificial Intelligence
Provides the conceptual basis for understanding current trends in Artificial Intelligence. Topics include both symbolic and numeric processing, intelligent search methods, problem representation, machine learning, expert systems, and a survey of some social implications of AI. Prerequisite: CPTR152. *Fall* (even years)

CPTR495 **(1–3)**
Independent Study
Directed study of material of special interest chosen in consultation with the instructor. No more than 6 credits may be earned in CPTR495. Graded S/U.

CPTR496 **(1–3)**
Special Projects
Project chosen in consultation with instructor. No more than 6 credits may be earned in CPTR495. Graded S/U.

CPTR536 **Alt (3)**
Compiler Construction
Storage allocation for programs, subroutine linkage, and code generation and optimization. Simple translator written in course. Prerequisites: CPTR276, 425. *Spring* (odd years)

CPTR548 **Alt (3)**
Advanced Database Systems
Database design and theory. Concurrency, distributed databases, integrity, security, query optimization, transaction processing, object-oriented databases. A survey of the design and implementation tradeoffs considered for these topics in the creation of available database packages. Includes a term project and reading from the literature. Prerequisite: CPTR467 or equivalent. *Spring* (odd years)

CPTR555 **Alt (3)**
Advanced Operating Systems
System structures and algorithms, reliability, security, distributed systems, study of operating systems highlighting these concepts, and recently published research in these and other areas. Includes a term project and readings from the literature. Prerequisite: CPTR440. *Spring* (even years)

CPTR556 **Alt (3)**
Real Time Systems
A survey of the system architecture and software engineering aspects of real time systems such as operating systems, and process-control software. Includes a term project and readings from current literature. Prerequisite: CPTR276. *Spring* (odd years)

CPTR557 **Alt (3)**
Advanced Network Computing and Architecture
A study of the concepts, conceptual design and implementation of the client/server, multi-tier and distributed models of computing. Consider topics such as physical media, protocols and layers, application programming interfaces, clustering, distributed computing and security from the perspective of a programmer using these tools as well as a system programmer and architect that creates and implements such tools, algorithms and models. Prerequisite: CPTR450 or equivalent. *Spring* (odd years)

CPTR560 **(3)**
Advanced Software Engineering
A study of applied software product development issues, including requirement analysis, systems and software design methodologies, software-project planning models (e.g., COCOMO), implementation, testing and reuse, language, tool and hardware selection, software economics, productivity measurement, risk management, statistical process evaluation, and control. Prerequisites: CPTR460, MATH182 or 141, STAT285. *Spring*

CPTR561, 562 **(2, 2)**
Software Engineering Group Project I, II
The implementation of a group project and the study of topics related to the group project including CASE tools, 4GL's, graphical user interfaces. Generally, the project begun in CPTR561 carries over to CPTR562. Corequisites: CPTR460, 560 respectively. *Fall, Spring*

CPTR568 **Alt (3)**
Advanced Computer Architecture
Functional analysis of computer hardware and supporting software systems. Includes a comparative study of past, present and proposed architectures as well as computer performance analysis and optimization. Additional topics may include parallel architectures and detailed CPU design issues. Prerequisite: CPTR465 or equivalent. *Spring* (even years)

CPTR585 **Alt (3)**
Advanced Computer Graphics
Advanced topics and current research in computer imaging—may include shading, ray tracing, radiosity, color spaces, lighting models, texture mapping, and recently published research in computer imagery. Includes term project and readings from the literature. Prerequisite: CPTR485. *Spring* (even years)

CPTR587 **Alt (3)**
Advanced Artificial Intelligence
Provides a forum for exploring current topics in machine intelligence through a survey of recent research results, independent readings, and hands-on projects. Typical topics include machine vision, speech recognition, natural language processing, and machine learning systems. Prerequisite: CPTR487. *Spring* (odd years)

CPTR625 **Alt (3)**
Analysis of Algorithms
Techniques for analyzing and designing algorithms, including average/worst case analysis, asymptotics, recurrences, empirical studies, intractability proofs (i.e., NP-Completeness) and heuristic alternatives. Application of techniques such as divide-and-conquer, graph, greedy, dynamic programming, backtracking, branch-and-bound, and probabilistic algorithms. Prerequisites: CPTR152, MATH142, STAT340. *Spring* (even years)

CPTR637 **Alt (3)**
Formal Methods
A survey of the different paradigms associated with formal methods. Applies formal methods to the specification, verification, and validation of software systems. Case studies are examined and a programming project is included. Prerequisites: CPTR460, MATH215, STAT285. *Spring* (even years)

CPTR660 **(0)**
Thesis/Project Extension

CPTR689 **(1–4)**
Topics in _____
Topics in computer science such as graphics, parallel processors, compiler design and optimization, communications and signal processing, distributed systems, graph theory, artificial intelligence, and formal theory. Repeatable with different topics to 6 credits. Prerequisite: Depends upon topic.

CPTR690 **(1–4)**
Independent Study
Directed study of material of special interest chosen in consultation with the instructor. May be repeated to 6 credits. Grade S/U.

CPTR698 **(1–4)**
Master's Research Project
Special project chosen in consultation with student's advisor and instructor. To be repeated to 6 credits. Grade S/U.

CPTR699 **(1–6)**
Master's Thesis
To be repeated to 6 credits. Graded S/U.

Engineering

ENGR120 **$ (2)**
Introduction to Engineering
Introduces students to the engineering profession. Various engineering disciplines, job functions, engineering designs and engineering ethics will be discussed. Students will use computer tools such as Mathcad, Microsoft PowerPoint and Excel Spread Sheet. A group project will be assigned. *Fall*

ENGR125 **$ (3)**
Engineering Graphics
Fundamentals of drawing as applied to mechanical engineering problems. Orthographic projections, auxiliary and sectional views, dimensioning and tolerancing, oblique and isometric views, detail and assembly drawing. Sketching and computer-aided drafting. Weekly: Two 1-hour lectures and two 1.5-hour labs. *Fall*

ENGR135 **(1)**
Descriptive Geometry
Solution of basic space problems. Determination of distances and angles, intersections of lines and surfaces, intersections of lines and development of surfaces. Prerequisite: ENGR125. *Spring*

ENGR180 **$ (4)**
Materials Science
Introduction to the study of materials used in industry. Deals with the fundamentals of structure and classification of materials. A weekly hands-on laboratory helps demonstrate the relationship of properties of materials studied in lecture. Weekly: 3 hours lecture and a 3-hour lab. Prerequisite: CHEM131. *Spring*

ENGR185 **(3)**
Engineering Statics
Principles of statics and their application to engineering problems; forces, moments, couples, friction, centroids and moments of inertia. Prerequisite or Corequisite: MATH141. *Spring*

ENGR225 **$ (3)**
Circuit Analysis
Resistive circuit analysis, network theorems, dependent sources, energy storage elements, 1st and 2nd order circuit transient responses, ac circuit analysis using phasors and impedances, and ac complex power. Weekly: 2 hours lecture and a 3-hour lab. Prerequisite MATH142, Corequisite MATH240. *Fall*

ENGR248 **(1–4)**
Workshop
Provides flexibility for the occasional workshop where it is appropriate to offer engineering credit. Workshop requirements must be approved by the department.

ENGR275 **$ (3)**
Electronics I
Introduction to diodes and transistors and their applications in switching and amplification circuits. Introduction to the basic op-amp circuits and their characteristics. Binary numbers and codes, Boolean algebra, logic circuits, flip-flops and registers. Digital circuit applications. Weekly: 2 hours lecture and a 3-hour lab. Prerequisite: ENGR225. *Spring*

ENGR285 **(3)**
Engineering Dynamics
Vectorial kinematics of moving bodies in fixed and moving reference frames. Kinetics of particles, assemblies of particles, and rigid bodies, with emphasis on the concept of momentum. Keplerian motion, elementary vibrations, and conservative dynamic systems. Prerequisites: ENGR185 and MATH142. *Spring*

ENGR310 **(3)**
Linear Systems Analysis
Convolution, analysis and spectra of continuous time domain signals, Fourier and Laplace transforms, discrete time domain signals, and the z-transform. Prerequisites: MATH215, 286. *Spring*

ENGR320 **(3)**
Manufacturing Processes
Covers traditional manufacturing practices such as machining processes (abrading, coating), and forming processes (cutting, forming, and assembling). Discusses non-traditional processes such as thermal, chemical, and pressure methods and explores special processes involved with specific materials such as plastics, woods, fibers, and other materials. Prerequisite: ENGR180. *Fall*

ENGR325 **$ (4)**
Electronics II
Modeling of transistors, biasing of transistors in amplifier circuits, and amplitude and frequency limitations of transistors. Linear and switching electronic circuits with an emphasis on op-amps. Weekly: 3 hours lecture and a 3-hour lab. Prerequisite: ENGR275. *Fall*

ENGR330 **(3)**
Thermodynamics
Introduction to the nature of energy and study of energy transport conservation in closed and flowing systems; properties and states of solids, liquids, vapors, and gases; enthalpy; meaning and production of entropy and introduction to cyclic systems. Prerequisite: PHYS242. *Fall*

ENGR335 **(3)**
Logic Circuit Design
Modern digital logic families, state machines, design of digital logic circuits in FPGAs, and VHDL specification of logic circuits. Prerequisite: ENGR275. *Fall*

ENGR340 **(3)**
Strength of Materials
Study of stresses and strain, deformations and deflections of posts, shafts, beams, columns; combined stresses; elasticity. Prerequisite: ENGR185. *Fall*

ENGR350 **$ (3)**
Sensors and Actuators
Study of temperature, mechanical, and optical sensors; sensor signal conditioning; ac, dc, and stepping motors; and the motor control requirements. Weekly: 2 lectures and a 3-hour lab. Prerequisite: ENGR275. *Spring*

ENGR360 **(3)**
Fluid Dynamics
Fluid statics and dynamics of fluid motion. Conservation of mass, momentum, and energy in laminar and turbulent flow. Boundary layer flow, lift and drag forces, viscous flow in conduits, open channel flow, flow measurements. Prerequisites: ENGR285, 330, MATH286. *Spring*

ENGR380 **$ (2)**
Programmable Controllers
Introduction to typical programmable logic controllers and their applications. Emphasis on programming and interfacing to electromechanical systems. Weekly: 1-hour lecture and a 3-hour lab. Prerequisite: ENGR275. *Spring*

ENGR385 **$ (4)**
Microprocessor Systems
Introduction to computer organization, microprocessors, assembly language programming, memory devices, I/O devices, interfacing with emphasis on control applications. Weekly: 3 hours lecture and a 3-hour lab. Prerequisite: ENGR335 or CPTR276. *Spring*

ENGR390 **$ (2)**
Mechanical Measurements Lab
Mechanical engineering lab work in thermodynamics, heat transfer, fluid mechanics, and material stress and strain. Weekly: Two 3-hour labs. Prerequisites: ENGR330, 340, Corequisites: ENGR350, 360. *Spring*

ENGR395/595 **S (2–6)**
Community Project in Engineering
"Hands-on" involvement in humanitarian and/or service-oriented projects. Work initiated by students requires prior approval of faculty. Graded on S/U basis. May be repeated for up to 6 credits.

ENGR410 **$ (4)**
Feedback Control Systems
Study of both analog and digital feedback control systems. Performance criteria and design and analysis methods. Weekly: 3 hours lecture and a 3-hour lab. Prerequisites: ENGR275, 285, and 310. *Fall*

ENGR415 **(3)**
Virtual Instrumentation
For engineering majors. Introduction to virtual instrumentation with emphasis on the sampling requirements and the signal conditioning requirements. Data logging and control applications. Prerequisite: ENGR275 and CPTR125 or 151. *Fall*

ENGR415-02 **(1)**
Virtual Instrumentation
Introduction to virtual instrumentation with emphasis on the sampling requirements and the signal conditioning requirements. Data logging and control applications. *Fall*

ENGR420 **(3)**
Machine Design
The design of machine elements and the calculations necessary in determining the size and shape of machine parts. The selection of materials and the application of standard machine components. Includes bearings, gears, clutches, and couplings. Prerequisites: ENGR320, 390. *Fall*

ENGR425 **(3)**
Project Management
Methodology used successfully to carry out a technical project including proposals, planning, work breakdown, scheduling, creativity, monitoring progress, and documentation. Prerequisite: STAT285 or 340. *Fall*

ENGR430 **(3)**
Quality Control
Analysis of the factors affecting product quality during manufacturing. Topics include use of basic statistics and probability for measurements, observations, sampling, control charts and reliability. Prerequisite: STAT285 or 340. *Spring*

ENGR435 **(3)**
Electromagnetic Fields
Study of static and dynamic electric and magnetic fields. Unbounded and bounded fields, fields in materials, force and torque, energy and potential functions, and Faraday induction. Propagation of electromagnetic energy; plane waves, transmission lines, and waveguides; radiation from dipole antennas; introduction to arrays. Prerequisites: MATH240, 286, PHYS242. *Fall*

ENGR440 **(3)**
Heat and Mass Transfer
Study of steady-state and transient heat conduction, forced and non-forced convection through ducts and over surfaces, black-body thermal radiation, solar radiation, heat exchangers, and mass transfer. Prerequisites: ENGR360, MATH286. *Spring*

ENGR450 **(2)**
Engineering Economy
Study of engineering decision methodology and criteria used to include economic factors in determining the best alternative in the design and selection of equipment, structures, methods, and processes. Prerequisites: MATH145 or MATH141. *Fall*

ENGR455 **$ (4)**
Communication Systems
Introduction to analog and digital communication systems; including topics in modulation; baseband and bandpass signals; power spectral density and bandwidth; random processes; noise, signal-to-noise ratio, and error probability; and system performance. Weekly: 3 hours lecture and a 3-hour lab. Prerequisites: ENGR310, 325, STAT340. *Spring*

ENGR465 **(3)**
Operations Analysis and Modeling
The methodology of mathematical modeling and its relation to solving problems in industrial and public systems. Linear programming, scheduling, queuing, simulation, optimization, and decision analysis. Prerequisites: MATH142, STAT340. May not be offered each year. *Spring*

ENGR470 **$ (3)**
Finite Element Methods
Introduction of finite element methods for the solution of problems in solid mechanics and heat transfer. Techniques for obtaining approximate numerical solutions to governing differential equations in the problem areas are covered. Industrial software is applied to the analysis and design of a broad range of engineering problems. Prerequisites: ENGR330, 340, MATH286. *Fall*

ENGR475 **(1–4)**
Topics in _____
Repeatable in different subjects (prerequisites depend on topic).

ENGR485 **(2–6)**
Community Project in Engineering
"Hands-on" involvement in humanitarian and/or service-oriented projects. Work initiated by students requires prior approval of faculty. Letter grade or graded on S/U basis. May be repeated for up to 6 credits.

ENGR491, 492 **(2, 2)**
Senior Design Project
A significant design project which culminates in a working system or a complete description of a proposed design. Both an oral and written presentation of the results of the project is required. Prerequisite: ENGR385 or 390. *Fall, Spring*

ENGR495 **(1–3)**
Independent Study
Individual study, research, or project in some field of engineering under the direction of a member of the engineering faculty. Prerequisite: permission of the person who will direct the study.

ENGR496 **(1–4)**
Cooperative Work Experience
Work experience in industry directed by an engineering faculty member. 120 hours of work is required per credit. A report must be submitted that summarizes the work experience and indicates the value of the experience to the student. Grade S/U. Repeatable to 4 credits. Prerequisite: junior/senior standing and permission of the person who will direct the study.

Engineering Management

ENGM520 **(3)**
Ergonomics and Work Design
The application of ergonomics and engineering principles to the design analysis and measurement of human work systems. *Spring*

ENGM530 **(3)**
Advanced Quality Control
Total quality management, analysis and use of state-of-the-art concepts and methods for total quality control and management. Probability studies and tests of significance. Prerequisite: STAT285 or 340. *Spring*

ENGM555 **(3)**
Facilities Planning
Planning and design of industrial and service facilities: site selection, process layout, materials handling, and storage. *Spring*

ENGM560 **(3)**
Production and Operations Analysis
Planning and control of manufacturing systems: design and management of production systems, strategies and competition for product design and processing, forecasting, inventory, supply chain management, operation scheduling and shop floor control. Prerequisites: MATH142, STAT285 or 340. *Fall*

ENGM565 **(3)**
Operations Analysis and Modeling
The development and use of mathematical models to analyze elements of production and service systems: linear programming, probabilistic models, game theory, dynamic programming, queuing theory, and simulation. Prerequisites: ENGR460; STAT285; MATH142 or 182. *Spring*

ENGM570 **(3)**
Project Management
Design and management of engineering projects: proposals, planning, resource requirements, organization, scheduling, and cost and schedule control. *Fall*

ENGM690 **(1–4)**
Independent Study
Individual study of research in some area of engineering management under the direction of a member of the engineering faculty.

ENGM698 **(2)**
Research
Research methods and a research project in an area of engineering management.