Industrial and Management Systems Engineering

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The industrial engineer (IE) provides leadership for American organizations in reestablishing competitiveness in the global marketplace through system integration and productivity improvement. No challenge to a young man or woman can be greater than improving productivity, which is the application of knowledge and skills to provide improved goods and services to enhance the quality of life, both on and off the job. This improvement must be achieved without waste of physical and human resources while maintaining the environmental balance. Industrial engineers are the "productivity people" who provide the necessary leadership and skills to integrate technology. This gives IEs a wide range of interests and responsibilities.

As in other engineering fields, industrial engineering is concerned with solving problems through the application of scientific and practical knowledge. What sets industrial engineering apart from other engineering disciplines is its broader scope. An IE relates to the total picture of productivity. An IE looks at the "big picture" of what makes society perform best—the right combination of human resources, natural resources, synthetic structures, and equipment. An IE bridges the gap between management and operations, dealing with and motivating people as well as determining what tools should be used and how they should be used.

An IE deals with people as well as things. In fact, industrial engineering is often called the "people-oriented profession." It is a primary function of the IE to integrate people and technology-oriented systems. Therefore, IEs are active in the fields of ergonomics and human factors.

To be competitive in this global economy, it is essential to emphasize and continually improve the quality of goods and services. Industrial engineering is the only engineering discipline offering course work in designing and implementing quality assurance systems.

The IE's skills are applicable to every kind of organization. IEs learn how to approach, think about, and solve productivity and integration problems regardless of their settings. IEs work in manufacturing facilities, banks, hospitals, government, transportation, construction, and social services. Within this wide variety of organizations, IEs get involved in projects such as designing and implementing quality control systems, independent work groups, the work flow in a medical laboratory, real-time production control systems, computer-based management information systems, and manufacturing operating systems, to name a few. A unique feature of most industrial engineering assignments is that they involve interdisciplinary teams. For example, the IE might be the leader of a team consisting of electrical and mechanical engineers, accountants, computer scientists, and planners. This IE program gives the student the skills necessary to be a leader of these teams. These skills include team building, brainstorming, group dynamics, and interpersonal relationships.

IEs have a sound background in technology integration, management theory and application, engineering economics and cost analysis. They are well equipped to deal with problems never seen before, making them prime candidates for promotion through the management career path, especially in high-tech organizations. In fact, more than half of all practicing IEs are in management positions. This area of expertise has placed the IE in the leadership role in the establishment of a new field of activity called "management of technology."

Industrial engineers are well trained in the development and use of analytical tools, and their most distinctive skill is in the area of model building. IEs must quickly learn and understand the problems of their clients. In this context, good people skills and good analytic skills are essential. This industrial engineering program offers both.

INDUSTRIAL ENGINEERING—B.S.E.

Degree Requirements

The following three courses are required to satisfy the mathematics content electives and microcomputer elective in the engineering core:

			Semester Hours
ECE	383	Probability and Statistics for Engineers	2
IEE	463	Computer-Aided Manufacturing and Control	3
MAT	242	Linear Algebra	2

In addition, the following courses are required for the Industrial Engineering major:

			Semester Hours
ASE	485	Engineering Statistics	3
IEE	205	Microcomputer Applications in Industrial Engineering	3
IEE	300	Economic Analysis for Engineers	3
IEE	305	Information Engineering	3
IEE	367	Methods Engineering and Facilities Design	4
IEE	374	Quality Control	3
IEE	431	Engineering Administration	3
IEE	461	Integrated Production Control	3
IEE	475	Introduction to Simulation	3
IEE	476	Operations Research Techniques/Applications	4
IEE	488	Industrial Engineering Analysis	3
IEE	490	Project in Design and Development	3
MET	343	Material Processes	4
Technical electives			10
Total			52

Technical Electives in Industrial Engineering

In consultation with an advisor, technical electives may be selected from one or more areas. A maximum of two courses are allowed outside the School of Engineering. Graduate courses may be taken for undergraduate credit, with department chair approval, provided the student has a GPA greater than or equal to 3.00.

Areas include communication/people skills, computer skills, integration skills, management skills, manufacturing skills, quality skills, and quantitative skills. See the *Manual of Undergraduate Study* in the Industrial and Management Systems Engineering office for specifics.

With departmental approval, technical electives may also be chosen from other courses in engineering, mathematics, the sciences, and business administration at or above the 300 level. A minimum of six hours of technical electives must be taken from the College of Engineering and Applied Sciences, with the approval of an advisor.

Industrial Engineering Program of Study Typical Four-Year Sequence

Freshman Year

First Semester

			Semester Hours
CHM	114	General Chemistry for Engineers[1]	4
ECE	105	Introduction to Languages of Engineering	3
ENG	101	First-Year Composition	3
MAT	270	Calculus with Analytic Geometry I	4
HU or SB elective[2]			3
Total			17

Second Semester

ECE	106	Introduction to Computer-Aided Engineering	3
ENG	102	First-Year Composition	3
MAT	271	Calculus with Analytic Geometry II	4
PHY	121	University Physics I: Mechanics	3
PHY	122	University Physics Laboratory I	1
HU or SB elective[2]			4
Total			18

Sophomore Year

First Semester

ECN	111	Macroeconomic Principles or ECN 112 Microeconomic Principles (3)	3
IEE	300	Economic Analysis for Engineers	3
MAT	242	Elementary Linear Algebra	2
MAT	272	Calculus with Analytic Geometry III	4
PHY	131	University Physics II: Electricity and Magnetism	3
PHY	132	University Physics Laboratory II	1
HU or SB elective[2]			2
Total			18

Second Semester

ECE	210	Engineering Mechanics I: Statics	3
ECE	383	Probability and Statistics for Engineers	2
IEE	205	Microcomputer Applications in Industrial Engineering	3
MAT	274	Elementary Differential Equations	3
Basic science elective[4]			3
L1 elective[2, 3]			3
Total			17

Junior Year

First Semester

ASE	485	Engineering Statistics	3
ECE	312	Engineering Mechanics II: Dynamics	3
IEE	367	Methods Engineering and Facility Design	4
IEE	374	Quality Control	3
IEE	431	Engineering Administration	3
HU or SB elective[2]			3
Total			19

Second Semester

ECE	301	Electrical Networks	4
ECE	340	Thermodynamics	3
ECE	350	Structure and Properties of Materials	3
IEE	305	Information Engineering	3
Technical electives			5
Total			18

Senior Year

First Semester

ECE	333	Electrical Instrumentation	3
IEE	461	Integrated Production Control	3
IEE	475	Introduction to Simulation	3
MET	343	Materials Processing	4
Technical electives			5
Total			18

Second Semester

ECE	400	Engineering Communications	3
IEE	463	Computer-Aided Manufacturing and Control	3
IEE	476	Operations Research Techniques/Applications	4
IEE	488	Industrial Engineering Analysis	3
IEE	490	Project in Design and Development	3
Total			16

Degree requirements: 133 semester hours minimum plus English proficiency.

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[1] Students who have taken no high school chemistry should take CHM 113 and 116.

[2] See pages 53–71 for the requirements and the approved list.

[3] See page 244 for special requirements and selection of an L1 elective.

[4] Must be an earth science or life science course; if physics or chemistry, the course must be of a more advanced level than CHM 114 or 116 or PHY 131.

Manufacturing Engineering

Manufacturing engineering is concerned with the application of the principles of science to increase productivity in industry. This involves the design of systems that allow for the best utilization of people, machines, material, and money. Modern manufacturing engineering is concerned with the application of technology, including computers, robots, graphics, mathematical and digital models, information and database systems, microtechnology, and systems theory.

Emphasis is placed on management and economics as well as technology. Graduates of the program are well qualified to participate in the introduction of CAD/CAM/CIM and factory automation technology to industry.

The following courses are required as part of the engineering core, mathematics content requirement and the microcomputer elective (only ECE 333 Electrical Instrumentation may be deleted from the engineering core):

			Semester Hours
ECE	350	Structure and Properties of Materials	3
ECE	383	Probability and Statistics for Engineers	2
IEE	463	Computer-Aided Manufacturing and Control	3

The basic science elective may be selected from BIO 181, CHM 331, GLG 100, PHY 361, and ZOL 201.

In addition, the following courses are required for the manufacturing engineering option:

			Semester Hours
IEE	205	Microcomputer Applications in Industrial Engineering	3
IEE	300	Economic Analysis for Engineers	3
IEE	305	Information Engineering	3
IEE	374	Quality Control	3
IEE	431	Engineering Administration	3
IEE	464	Concurrent Engineering Design	3
IEE	490	Project in Design and Development	3
MAE	317	Dynamic Systems and Control	4
MET	331	Design for Manufacturing I	3
MET	343	Material Processes	4
MET	438	Design for Manufacturing II	4
MET	443	N/C Computer Programming	3
MET	451	Introduction to Robotics	3
Technical electives*			10
Total			52

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* Two courses of engineering science and one course of engineering design content required.

INDUSTRIAL AND MANAGEMENT SYSTEMS ENGINEERING

IEE 205 Microcomputer Applications in Industrial Engineering. (3) F, S
Concepts related to development of operational capability in the use of microcomputer hardware, software, and networking as related to industrial engineering applications. Prerequisite: ECE 105. *General studies: N3.*

300 Economic Analysis for Engineers. (3) F, S
Economic evaluation of alternatives for engineering decisions, emphasizing the time value of money. Prerequisite: MAT 270.

305 Information Systems Engineering. (3) F
Emphasis on systems analysis, design and implementation of information systems using fourth generation languages and alternative data base structures. Prerequisite: IEE 205.

367 Methods Engineering and Facilities Design. (4) F
Analysis and design of work systems; productivity; motion and time study techniques; human factors. Analysis and design of facilities for automated and man-machine systems; emphasis on process design, material handling, layout design, and facilities location. Lecture, lab. Prerequisites: IEE 205 (or equivalent), 300.

374 Quality Control. (3) F
In-depth analysis of control chart and other statistical process control techniques. Organization and managerial aspects of quality assurance. Attribute and variable acceptance sampling plans. Prerequisite: ECE 383.

411 Engineering Economy. (3) N
Equipment replacement analysis, treatment of inflation in cash flow studies, and consideration of risk and uncertainty. Prerequisite: IEE 300.

422 Information Systems Design. (3) N
Emphasis on the application of system analysis and design to information systems. Microprocessor MIS project required. Prerequisite: IEE 205 or equivalent.

431 Engineering Administration. (3) F
Engineering organization and administration; introduction to decision making, quantitative and qualitative approaches to management, and engineering administration.

437 Human Factors Engineering. (3) F
Study of people at work; designing for human performance effectiveness and productivity. Considerations of human physiological and psychological factors. Prerequisite: IEE 367.

461 Integrated Production Control. (3) F
Production control techniques for the planning, analysis, control, and evaluation of operating systems. Time series forecasting, network planning, scheduling, and control. Prerequisites: ECE 383; IEE 205 or equivalent.

463 Computer-Aided Manufacturing and Control. (3) F, S
Emphasis on computer control in manufacturing; real time concepts, CIM, NC, group technology and process planning, and robotics. Prerequisite: IEE 205 or equivalent. *General studies: N3.*

464 Concurrent Engineering. (3) S
Concurrent engineering refers to simultaneous consideration of product, manufacturing process, and service issues in product design. The course covers issues and methods to solve this more complex design problem. Prerequisites: ECE 106; IEE 205 or equivalent.

475 Introduction to Simulation. (3) F, S
Use of simulation in the analysis and design of network and discrete systems. Methods for using a simulation language. Introduction to statistical aspects to simulation. Prerequisites: ECE 383; IEE 205 or equivalent. *General studies: N3.*

476 Operations Research Techniques/Applications. (4) F, S
Topics include linear programming, network optimization, dynamic programming, Markov processes, and queuing models. Emphasis on the design and development of models for solving decision problems in industrial systems. Prerequisites: ECE 383; MAT 242. *General studies: N2.*

488 Industrial Engineering Analysis. (3) S
Labor material and overhead cost analysis, parametric cost estimating, risk analysis involving budget limitations, assurance of estimates, quality cost systems, and life cycle cost analysis, including effects on engineering design, reliability, maintainability, serviceability, testability, and availability. Prerequisites: ECE 383; IEE 300.

490 Project in Design and Development. (3) F, S
Individual project in creative design and synthesis. Prerequisite: senior standing.

501 Foundations of Industrial Engineering I. (3) N
Techniques for the analysis and design of man-machine systems. Emphasis on work planning, methods, measurements, material handling, and facility design. Not available for I.E. graduate credit.

502 Foundations of Industrial Engineering II. (3) N
Introduction to quantitative production control techniques, including planning, forecasting, inventory control and MRP, and scheduling. Influence of CAD/CAM and automation on production control process. Not available for I.E. graduate credit. Prerequisite: ECE 383 or 500.

503 Economic Analysis for Engineers. (3) F, S
Economic evaluation of alternatives for engineering decisions, emphasizing the time value of money. Not available for I.E. graduate credit. Prerequisite: MAT 270.

504 Math Tools/Industrial Engineers. (3) N
Introduction to, and extension of, fundamental mathematical techniques. Extensive use of a comprehensive, computer based, mathematical environment to both explore and verify mathematical theorems and problems, linear algebra probability/statistics optimization, transform theory, and logic.

505 Applications Engineering. (3) F
Develop working knowledge of application systems development tools needed for computer integrated enterprise. Includes techniques for application generation in fourth and fifth generation software environments. Topics include client server network systems, decision support systems, and transaction systems in distributed environment.

510 Measurement of Productivity. (3) S ’95
The engineering economic audit and its use with applications to break-even analysis, variable budget control cost analysis, and product pricing. Prerequisites: ECE 383 or 500; IEE 205 or equivalent.

511 Analysis of Decision Processes. (3) S
Methods of making decisions in complex environments and statistical decision theory; effects of risk, uncertainty, and strategy on engineering and managerial decisions. Prerequisite: ECE 383 or 500.

520 Ergonomics Design. (3) S
Human physiological and psychological factors in the design of work environments and in the employment of people in man-machine systems. Open-shop lab assignments in addition to class work. Prerequisite: IEE 437 or 547.

531 Topics in Engineering Administration. (3) S ’96
Consideration given to philosophical, psychological, political, and social implications of administrative decisions. Prerequisite: IEE 532 or permission of instructor.

532 Management of Technology. (3) F
Topics include designing a technical strategy; technological forecasting; interfacing marketing engineering and manufacturing; designing and managing innovation systems; creativity; application of basic management principles to technology management. Prerequisite: IEE 431 or 541 or instructor approval.

533 Scheduling and Network Analysis Models. (3) S ’96
Application of scheduling and sequencing algorithms, deterministic and stochastic network analysis, and flow algorithms. Prerequisites: ECE 383 or 500; IEE 476 or 546.

540 Engineering Economy. (3) N
Equipment replacement analysis, treatment of inflation in cash flow studies, and consideration of risk and uncertainty. Open only to students without previous credit for IEE 411. Prerequisite: IEE 300 or 503.

541 Engineering Administration. (3) F, SS
Engineering organization and administration; introduction to decision making; quantitative and qualitative approaches to management and engineering administration. Open only to students without previous credit for IEE 431.

542 Information System Design. (3) N
Emphasis on the application of system analysis and design to information systems. Microprocessor MIS project required. Open only to students without previous credit for IEE 422. Prerequisite: IEE 205 or equivalent.

543 Computer-Aided Manufacturing and Control. (3) F, S
Emphasis on computer control in manufacturing real-time concepts. CIM, NC, group technology and process planning, and robotics. Open only to students without previous credit for IEE 463. Prerequisite: IEE 205 or equivalent

544 Concurrent Engineering. (3) S
Concurrent engineering refers to simultaneous consideration of product, manufacturing process, and service issues in product design. The course covers issues and methods to solve this more complex design problem. Open only to students without previous credit for IEE 464. Prerequisites: ECE 106; IEE 205 or equivalent.

545 Introduction to Simulation. (3) F, S
Use of simulation in the analysis and design of network and discrete systems. Methods for using a simulation language. Introduction to statistical aspects of simulation. Open only to students without previous credit for IEE 475. Prerequisites: ECE 383 or 500; IEE 205 or equivalent.

546 Operations Research Techniques/Applications. (4) F, S
Topics include linear programming network optimization, dynamic programming, Markov processes, and queuing models. Emphasis on the design and development of models for solving decision problems in industrial systems. Open only to students without previous credit for IEE 476. Prerequisites: ECE 383 or 500; MAT 242.

547 Human Factors Engineering. (3) F
Study of people at work; designing for human performance effectiveness and productivity. Considerations of human physiological and psychological factors. Open only to students without previous credit for IEE 437.

548 Industrial Engineering Analysis. (3) S
Labor material and overhead cost analysis, parametric cost estimating, risk analysis involving budget limitations, assurance of estimates, quality cost systems, and life cycle analysis, including effects on engineering design, reliability, maintainability, serviceability, testability, and availability. Open only to students without previous credit for IEE 488. Prerequisites: ECE 383 or 500; IEE 300 or 503.

552 Strategic Technological Planning. (3) S
Study of concept of strategy, strategy formulation process, and strategic planning methodologies with emphasis on engineering design and manufacturing strategy, complemented with case studies. An analytical executive planning decision support system is presented and used throughout course. Pre- or corequisite: IEE 545 or 566 or 567 or 574 or 575.

560 Database Concepts for Industrial Management Systems. (3) S
Application of data base concepts to industrial systems problems. Topics include conceptual modeling, data structures, database software, and perspectives from expert and knowledge base systems.

561 Production Control Information Systems. (3) F
Development of information system designs for production control. Topics include MRP I, MRP II, scheduling, sequencing, and inventory control. On-line design concepts are covered. Prerequisites: ASE 485 or 500; IEE 461; MAT 242.

562 Computer-Aided Manufacturing (CAM) Tools. (3) F
Current topics in automation, distributed control, control code generation, control logic validation, CAM integration, CAD/CAM data structures, planning for control systems. Topics vary by semester. Prerequisite: IEE 463 or 543 or equivalent.

563 Systems Analysis for Distributed Systems. (3) S
Analysis and design of distributed systems for computer integrated manufacturing and information processing. Concepts of host driven microprocessors to collect, store, and communicate data. Prerequisite: ECE 383 or 500.

564 Planning for Computer-Integrated Manufacturing. (3) F
Theory and use of IDEF methodology in planning for flexible manufacturing, robotics, and real-time control. Simulation concepts applied to computer-integrated manufacturing planning. Prerequisite: IEE 463 or 543.

565 Computer-Integrated Manufacturing Research. (3) S
Determination and evaluation of research areas in computer-integrated manufacturing, including real-time software, manufacturing information systems, flexible and integrated manufacturing systems, robotics, and computer graphics. Prerequisite: IEE 564.

566 Simulation in Computer-Integrated Manufacturing Planning. (3) F
Use of simulation in the planning of computer-integrated manufacturing planning related to robotics, flexible, and integrated manufacturing systems. Use of computer graphics combined with simulation analysis for CIM decision support. Prerequisite: IEE 475 or 545.

567 System Simulation. (3) F
Use of simulation in the analysis and design of systems involving continuous and discrete processes; simulation languages; statistical aspects of simulation. Prerequisite: IEE 475 or 545.

569 Advanced Statistical Methods. (3) F ’94
Application of statistical inference procedures, based on ranks, to engineering problems. Efficient alternatives to classical statistical inference constrained by normality assumptions. Prerequisite: ASE 485 or 500.

570 Advanced Quality Control. (3) S
Economic-based acceptance sampling, multiattribute acceptance sampling, narrow limit gauging in inspector error and attributes acceptance sampling, principles of quality management, and selected topics from current literature. Prerequisite: ASE 485 or 500 or equivalent.

571 Quality Management. (3) F
Total quality concepts, quality strategies, quality and competitive position, quality costs, vendor relations, the quality manual, and quality in the services. Prerequisite: IEE 431 or 541.

572 Design of Engineering Experiments. (3) F, S
Analysis of variance and experimental design. Topics include general design methodology, incomplete blocks, confounding, fractional replication, and response surface methodology. Prerequisite: ASE 485 or 500.

573 Reliability Engineering. (3) S
Topics include the nature of reliability, time to failure densities, especially the exponential and Weibull, series/parallel/standby systems, complex system reliability, Bayesian reliability analysis, and sequential reliability tests. Prerequisite: ECE 383 or 500.

574 Applied Deterministic Operations Research Models. (3) F
Formulation, solution, analysis, and application of deterministic models in operations research, including those of linear programming, integer programming, and nonlinear programming. Prerequisite: IEE 476 or 546.

575 Applied Stochastic Operations Research Models. (3) S
Application of stochastic models, including inventory theory, queuing theory, Markov processes, stochastic programming, and renewal theory. Prerequisite: ASE 485 or 500.

576 Applications of Operations Research. (3) N
Case studies of application of linear and nonlinear models and general types of search techniques. Prerequisite: IEE 574 or instructor approval.

577 Decision and Expert Systems Methodology. (3) F
Systems approach to the analysis, design, and implementation of decision support systems. Emphasis on development of databases, model bases dialogs, and systems architecture as well as systems effectiveness. Introduction to expert systems as decision aid included. Term project required. Prerequisite: IEE 205 or equivalent.

578 Regression Analysis. (3) F
A course in regression model building oriented toward engineers/physical scientists. Topics include linear regression, diagnostics biased and robust fitting, nonlinear regression. Prerequisite: ASE 485 or 500.

579 Time Series Analysis and Forecasting. (3) F ’95
Forecasting time series by the Box-Jenkins and exponential smoothing techniques; existing digital computer programs are utilized to augment the theory. Prerequisites: ASE 485 or 500; IEE 461.

582 Response Surfaces and Process Optimization. (3) S
An introduction to response surface method and its applications. Topics include steepest ascent, canonical analysis, designs, and optimality criteria. Prerequisite: IEE 572.

678 Advanced Decision Theory. (3) N
Advanced decision theory techniques for industrial systems. Topics include conjugate families of distributions, value theory, decisions with multiple objectives, and goal programming. Prerequisite: IEE 511.

681 Reliability, Availability, and Serviceability. (3) F ’94
Includes organizing for RAS, hardware and software RAS, integrity and fault-tolerant design, maintenance design and maintenance strategy, Markov models for RAS, fault-free analysis, and military standards for RAS. Prerequisite: ECE 383 or 500.

Omnibus Courses: See page 44 for omnibus courses that may be offered.

Mechanical and Aerospace Engineering

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ASSOCIATE PROFESSORS
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ASSISTANT PROFESSORS
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PROFESSORS EMERITI
AVERY, BEAKLEY, S. CHEN, DITSWORTH, FRY, KAUFMAN, LOGAN, RICE, SHAW, THOMPSON, TURNBOW, WILCOX, WOOLDRIDGE

The Department of Mechanical and Aerospace Engineering is the administrative home for two undergraduate majors: Aerospace Engineering and Mechanical Engineering.

Both majors build on the broad exposure to the engineering, chemical, and physical sciences and the mathematics embodied in the general studies and engineering core courses required of all engineering students.

The *Aerospace Engineering* major provides students an education in technological areas critical to the design and development of aerospace vehicles and systems. Aerospace Engineering graduates are typically employed at government laboratories (e.g., NASA) and in a wide range of aerospace and mechanical industries. The *Mechanical Engineering* major is perhaps one of the most broadly applicable programs in engineering, providing education for a wide variety of employment opportunities.

The two majors, discussed in more detail below, can serve as entry points to immediate professional employment or to graduate study. The emphasis in all fields is on the development of fundamental knowledge that will have long-lasting utility in our rapidly changing technical society. Employers' desire for this emphasis is a strong point in favor of these choices of curricula over technology or special programs that emphasize current applications or specific industries.

DEGREE REQUIREMENTS

All degree programs in the department require that students attain a minimum GPA of 2.00 in the engineering core and in the major in order to be eligible for graduation. Also, the department may require additional or remedial work for those students who have demonstrated a trend of academic difficulty.

Engineering Core Options

Among the options listed on page 244 as part of the engineering core requirements, students in the Department of Mechanical and Aerospace Engineering are required to select the following:

			Semester Hours
ECE	210	Engineering Mechanics I: Statics	3
ECE	312	Engineering Mechanics II: Dynamics	3
ECE	313	Introduction to Deformable Solids	3
ECE	340	Thermodynamics	3
ECE	350	Structure and Properties of Materials	3
MAE	305	Measurements and Microcomputers	4

AEROSPACE ENGINEERING—B.S.E.

The primary concern of aerospace engineers is the design and development of a wide variety of aircraft and space vehicles and systems. The current challenges to the aerospace engineer include the design of a new generation of high efficiency transport aircraft, the development of the next generation of space transports, and the design of large space systems. In addition to the design of vehicles, the aerospace engineer is involved in the further development of the many spin-offs of the aerospace industry. These include contributions to power generation, communications, air and water pollution monitoring, management of the earth's resources, and the understanding of weather. Future contributions are anticipated in the area of zero-gravity manufacturing of high-purity materials and medicines, and the design of solar power satellites.

The undergraduate curriculum includes the study of flight mechanics, aerospace structures and materials, aerodynamics and propulsion. These subjects provide the foundation necessary for design of aircraft and space vehicles.

Aerospace Engineering Major

Aerospace Engineering students are required to select the following courses in the engineering core:

			Semester Hours
ECE	386	Partial Differential Equations for Engineers.	2
MAT	342	Linear Algebra	3
PHY	361	Introductory Modern Physics	3

The Aerospace Engineering major consists of the following courses:

			Semester Hours
MAE	317	Dynamic Systems and Control	4
MAE	361	Aerodynamics I	3
MAE	413	Spacecraft Dynamics and Control	3
MAE	415	Vibration Analysis	4
MAE	425	Aerospace Structures I	3
MAE	426	Aerospace Structures II	4
MAE	441	Design Theory and Techniques	3
MAE	460	Gas Dynamics	3
MAE	461	Aerodynamics II	3
MAE	462	Dynamics of Flight	3
MAE	463	Propulsion	3
MAE	464	Aerospace Laboratory	2
MAE	467	Aircraft Performance	3
MAE	468	Aerospace Systems Design	3
Area of emphasis (technical electives)			6
Total			50

Aerospace Engineering Areas of Emphasis

Technical electives may be selected from among any of the courses listed below or from courses listed under the Mechanical Engineering areas of emphasis. The courses are grouped so that the student may select an elective package of closely related courses. A student may, with prior approval of the advisor and department, select a general area and a corresponding set of courses not listed below that would support a career objective not covered by the following categories.

Aerodynamics. MAE 434, 466, 471, 490; MAT 466.

Aerospace Materials. ECE 383; MAE 455; MSE 355, 420, 440, 441, 450, 470.

Aerospace Structures. ECE 383; MAE 404, 455, 490.

Computer Methods. ASE 485; CSE 310, 320, 422, 428; ECE 383; IEE 463, 464, 475; MAE 403, 404, 406, 471, 541; MAT 464, 465, 466.

Design. MAE 341, 403, 404, 406, 435, 442, 446, 455, 466, 490; MSE 440, 441.

Mechanical. Any courses listed under Mechanical Engineering Areas of Emphasis.

Propulsion. MAE 382, 434, 436, 465, 489, 490.

System Dynamics and Control. CSE 428; ECE 383; EEE 480, 482; MAE 417, 447, 490.

Aerospace Engineering Program of Study Typical Four-Year Sequence

The first two years are usually devoted to the general studies and engineering core requirements. Thus, the degree programs in the department share essentially the same course schedule for that period of time. A typical schedule is given below:

Program of Study Typical Four-Year Sequence

Freshman Year

First Semester			*Semester Hours*
CHM	114	General Chemistry for Engineers or CHM 116 General Chemistry (4)	4
ECE	105	Introduction to Languages of Engineering	3
ENG	101	First-Year Composition	3
MAT	290	Calculus I	5
HU or SB elective[1]			3
Total			18

Second Semester			
ECE	106	Introduction to Computer-Aided Engineering	3
ENG	102	First-Year Composition	3
MAT	291	Calculus II	5
PHY	121	University Physics I: Mechanics	3
PHY	122	University Physics Laboratory I	1
HU or SB elective[1]			3
Total			18

Sophomore Year

First Semester			
ECE	210	Engineering Mechanics I: Statics	3
MAT	342	Linear Algebra	3
MAT	274	Elementary Differential Equations	3
PHY	131	University Physics II: Electricity and Magnetism	3
PHY	132	University Physics Laboratory II	1
L1 elective[1, 2]			3
Total			16

Second Semester			
ECE	301	Electrical Networks I	4
ECE	312	Engineering Mechanics II: Dynamics	3
ECE	313	Introduction to Deformable Solids	3
ECE	340	Thermodynamics	3
ECE	350	Structure and Properties of Materials.	3
ECE	386	Partial Differential Equations for Engineers	2
Total			18

Junior Year

First Semester			*Semester Hours*
MAE	305	Measurements and Microcomputers	4
MAE	361	Aerodynamics I	3
MAE	413	Spacecraft Dynamics and Control	3
MAE	425	Aerospace Structures I	3
PHY	361	Introductory Modern Physics	3
HU or SB elective[1]			3
Total			19

Second Semester			
MAE	317	Dynamic Systems and Control	4
MAE	426	Aerospace Structures II	4
MAE	441	Design Theory and Techniques	3
MAE	460	Gas Dynamics	3
MAE	467	Aircraft Performance	3
Total			17

Senior Year

First Semester			
MAE	415	Vibration Analysis	4
MAE	461	Aerodynamics II	3
MAE	462	Dynamics of Flight	3
MAE	463	Propulsion	3
HU or SB elective[1]			3
Total			16

Second Semester			
ECE	400	Engineering Communications	3
MAE	464	Aerospace Laboratory	2
MAE	468	Aerospace Systems Design	3
HU or SB elective[1]			3
Technical electives			6
Total			17

[1] See pages 53–71 for the specific requirements and the approved list.

[2] See page 244 for special requirements and selection of an L1 elective.

MECHANICAL ENGINEERING—B.S.E.

Mechanical engineering is a creative discipline that draws upon a number of basic sciences to design the devices, machines, processes, and systems that involve mechanical work and its conversion from and into other forms. It includes: the conversion of thermal, chemical, and nuclear energy into mechanical energy through various engines and power plants; the transport of energy via devices like heat exchangers, pipelines, gears, and linkages; the use of energy to perform a variety of tasks for the benefit of society, such as in transportation vehicles of all types, manufacturing tools and equipment, and household appliances. Furthermore, since all manufactured products must be constructed of solid materials and because most products contain parts that transmit forces, Mechanical Engineering is involved in the structural integrity and materials selection for almost every product on the market.

Mechanical engineers are employed in virtually every kind of industry. They are involved with seeking new knowledge through research, with doing creative design and development, and with the construction, control, management, and sales of the devices and systems needed by society. Therefore, a major strength of a mechanical engineering education is the flexibility it provides in future employment opportunities for its graduates.

The undergraduate curriculum includes the study of: the principles governing the use of energy; the principles of design, instruments and control devices; and the application of these studies to the creative solution of practical, modern problems.

Mechanical Engineering Major

Mechanical Engineering students are required to select the following courses in the engineering core:

			Semester Hours
ECE	386	Partial Differential Equations for Engineers	2
MAT	242	Elementary Linear Algebra	2
PHY	361	Introductory Modern Physics	3

The Mechanical Engineering major requires the following courses:

			Semester Hours
ECE	384	Numerical Analysis for Engineers I	2
MAE	317	Dynamic Systems and Control	4
MAE	371	Fluid Mechanics	3
MAE	372	Fluid Mechanics	4
MAE	382	Thermodynamics	3
MAE	388	Heat Transfer	3
MAE	415	Vibration Analysis	4
MAE	422	Mechanics of Materials	4
MAE	441	Design Theory and Techniques	3
MAE	442	Mechanical Systems Design or MAE 446 Thermal Systems Design (3)	3
MAE	443	Engineering Design	3
MAE	490	Projects in Design and Development	2
MAE	491	Experimental Mechanical Engineering	3
Area of emphasis (technical electives)			10
Total			51

Mechanical Engineering Areas of Emphasis

Technical electives may be selected from among any of the courses listed below or from courses listed under the Aerospace Engineering areas of emphasis. The courses are grouped so that the student may select an elective package of closely related courses. With prior approval of the advisor and department, a student may select a general area and a corresponding set of courses not listed below that would support a career objective not covered by the following categories.

Aerospace. Any courses listed under Aerospace Engineering areas of emphasis.

Biomechanical. BME 411, 412, 416, 419, 517 (recommended); EEE 302, 434.

Computer Methods. ASE 485; CSE 310, 422, 428; ECE 383; IEE 463, 464, 475; MAE 403, 404, 406, 471, 541; MAT 464, 465, 466.

Control and Dynamic Systems. CSE 428; ECE 383; EEE 360; IEE 463; MAE 413, 417, 462, 467.

Design. MAE 341, 351, 403, 404, 406, 417, 434, 435, 438, 442, 446, 447.

Energy Systems. EEE 360; MAE 430, 434, 435, 436, 437, 438, 446.

Engineering Mechanics. MAE 341, 402, 404, 413, 426, 442, 460, 461, 471; MAT 464, 466.

Manufacturing. CSE 428; IEE 300, 374, 411, 461, 463; MAE 341, 351, 403, 404, 442, 447, 455; MSE 355, 420, 431, 440.

Stress Analysis, Failure Prevention, and Materials. ECE 383; MAE 341, 404, 426, 447, 455; MSE 355, 420, 431, 440, 450.

Thermosciences. MAE 336, 430, 434, 435, 436, 437, 446, 460, 463, 471.

Mechanical Engineering Program of Study Typical Four-Year Sequence

Freshman Year

First Semester

			Semester Hours
CHM	114	General Chemistry for Engineers or CHM 116 General Chemistry (4)	4
ECE	105	Introduction to Languages of Engineering	3
ENG	101	First-Year Composition	3
MAT	290	Calculus I	5
HU or SB elective[1]			3
Total			18

Second Semester

ECE	106	Introduction to Computer-Aided Engineering	3
ENG	102	First-Year Composition	3
MAT	291	Calculus II	5
PHY	121	University Physics I: Mechanics	3
PHY	122	University Physics Laboratory I	1
HU or SB elective[1]			3
Total			18

Sophomore Year

First Semester

ECE	210	Engineering Mechanics I: Statics	3
MAT	242	Elementary Linear Algebra	2
MAT	274	Elementary Differential Equations	3
PHY	131	University Physics II: Electricity and Magnetism	3
PHY	132	University Physics Laboratory II	1
HU or SB elective[1]			3
L1 elective[1, 2]			3
Total			18

Second Semester

ECE	301	Electrical Networks I	4
ECE	312	Engineering Mechanics II: Dynamics	3
ECE	313	Introduction to Deformable Solids	3
ECE	340	Thermodynamics	3
ECE	350	Structure and Properties of Materials	3
ECE	386	Partial Differential Equations for Engineers	2
Total			18

Junior Year

First Semester

ECE	384	Numerical Analysis for Engineers I	2
MAE	305	Measurements and Microcomputers	4
MAE	371	Fluid Mechanics	3
MAE	382	Thermodynamics	3
MAE	422	Mechanics of Materials	4
PHY	361	Introductory Modern Physics	3
Total			19

Second Semester

MAE	317	Dynamic Systems and Control	4
MAE	372	Fluid Mechanics	4
MAE	388	Heat Transfer	3
MAE	441	Design Theory and Techniques	3
HU or SB elective[1]			3
Total			17

Senior Year

First Semester

MAE	415	Vibration Analysis	4
MAE	442	Mechanical Systems Design or MAE 446 Thermal Systems Design (3)	3
MAE	491	Experimental Mechanical Engineering	3
Technical electives			6
Total			16

Second Semester

ECE	400	Engineering Communications	3
MAE	443	Engineering Design	3
MAE	490	Projects in Design and Development	2
HU or SB elective[1]			3
Technical electives			4
Total			15

[1] See pages 53–71 for the requirements and the approved list.

[2] See page 244 for special requirements and selection of an L1 elective.

SPECIAL PROGRAMS

An engineering mechanics option is available under the Engineering Special Studies. See pages 278–279 for details and course requirements.

MECHANICAL AND AEROSPACE ENGINEERING

MAE 305 Measurements and Microcomputers. (4) F, S
Science of measurements, microcomputer architecture and fundamentals, and interfacing microcomputers to laboratory experiments, sensors, and data acquisition. Lecture, lab. Prerequisite: ECE 301.

317 Dynamic Systems and Control. (4) F, S
Modeling and representations of dynamic physical systems, including transfer functions, block diagrams, and state equations. Transient response. Principles of feedback control and linear system analysis, including root locus and frequency response. Lecture, lab. Prerequisites: ECE 301, 312. Pre- or corequisite: ECE 386.

336 Air Conditioning and Refrigeration. (3) F
Refrigeration cycles, refrigerant properties, heating, and cooling loads; psychrometry and purification; temperature and humidity control. Prerequisite: MAE 382 or MET 432 or instructor approval.

341 Mechanism Analysis and Design. (3) F
Positions, velocities, and accelerations of machine parts; cams, gears, flexible connectors, and rolling contact; introduction to synthesis. Prerequisite: ECE 312.

351 Manufacturing Processes Survey. (3) F, S
Production techniques and equipment. Casting and molding, pressure forming, material removal, joining and assembly processes, automation, and material handling. Lecture, recitation. Prerequisite: ECE 350.

361 Aerodynamics I. (3) F, S
Fluid statics, conservation principles, stream function, velocity potential, vorticity, inviscid flow, Kutta-Joukowski, thin-airfoil theory, and panel methods. Prerequisites: ECE 312, 340.

371 Fluid Mechanics. (3) F, S
Introductory concepts of fluid motions; fluid statics; control volume forms of basic principles; introduction to local principles. Prerequisites: ECE 312, 340.

372 Fluid Mechanics. (4) F, S
Application of basic principles of fluid mechanics to problems in viscous and compressible flow. Lab experimentation, demonstrations. Prerequisites: ECE 384, 386; MAE 371.

382 Thermodynamics. (3) F, S
Applied thermodynamics; gas mixtures, psychrometrics, property relationships, power and refrigeration cycles, and reactive systems. Prerequisite: ECE 340.

388 Heat Transfer. (3) F, S
Steady and unsteady heat conduction, including numerical solutions; thermal boundary layer concepts and applications to free and forced convection. Thermal radiation concepts. Prerequisite: MAE 371.

402 Introduction to Continuum Mechanics. (3) S
Application of the principles of continuum mechanics to such fields as flow in porous media, biomechanics, electromagnetic continua, and magneto-fluid mechanics. Prerequisites: ECE 313; MAE 361 or 371; MAT 242 or 342.

403 CAD Systems Development. (3) S
Design and implementation of CAD System, user interface design, computer graphics, data structures, and extensive code development. Prerequisites: ECE 105 or equivalent; junior standing in program.

404 Finite Elements in Engineering. (3) S
Introduction to ideas and methodology of finite element analysis. Applications to solid mechanics, heat transfer, fluid mechanics, and vibrations. Prerequisites: ECE 313; MAT 242 or 342.

406 CAD/CAM Applications in MAE. (3) F
Solution of engineering problems with the aid of state-of-the-art software tools in solid modeling, engineering analysis, and manufacturing; selection of modeling parameters; reliability tests on software. Prerequisite: instructor approval.

413 Spacecraft Dynamics and Control. (3) F, S
Kinematics of particles and rigid bodies, Euler's moment equations, satellite orbits and maneuvers, and spacecraft attitude dynamics and control. Prerequisites: ECE 312; MAT 242 or 342.

415 Vibration Analysis. (4) F, S
Free and forced response of single and multiple degree of freedom systems, continuous systems; applications in mechanical and aerospace systems numerical methods. Lecture, lab. Prerequisites: ECE 312; MAE 305, 422 (or 425); MAT 242 or 342.

417 Control System Design. (3) S
Tools and methods of control system design and compensation, including simulation, response optimization, frequency domain techniques, state variable feedback, and sensitivity analysis. Introduction to nonlinear and discrete time systems. Prerequisite: MAE 317.

422 Mechanics of Materials. (4) F, S
Failure theories, energy methods, finite element methods, plates, torsion of noncircular members, unsymmetrical bending, shear center, and beam column. Lecture, lab. Prerequisites: ECE 313; MAT 242 or 342. Pre- or corequisite: ECE 386.

425 Analysis of Aerospace Structures. (3) F, S
Stability, energy methods, finite elements, torsion, unsymmetrical bending, bending and torsion of multicelled structures. Prerequisites: ECE 313; MAT 242 or 342.

426 Design of Aerospace Structures. (4) F, S
Flight vehicle loads, design of semi-monocoque structures, local buckling and crippling, fatigue, aerospace materials, composites, joints, and finite element applications. Lecture, lab. Prerequisites: MAE 361, 425.

430 Introduction to Nuclear Engineering. (3) F
Neutron interactions with matter. Principles of neutron chain reacting systems. Neutron diffusion and moderation. Heat removal from nuclear reactors. Point reactor kinetics. Prerequisite: PHY 361.

434 Internal Combustion Engines. (3) S
Performance characteristics, combustion, carburetion and fuel-injection, and the cooling and control of internal combustion engines. Computer modeling. Lab. Prerequisite: MAE 382.

435 Turbomachinery. (3) S
Design and performance of turbomachines, including steam, gas and hydraulic turbines, centrifugal pumps, compressors, fans, and blowers. Pre- or corequisite: MAE 372 or 461.

436 Combustion. (3) N
Thermochemical and reaction rate processes; combustion of gaseous and condensed-phase fuels. Applications to propulsion and heating systems. Pollutant formation. Prerequisite: MAE 382.

437 Direct Energy Conversion. (3) N
Unconventional methods of energy conversion; fuel cells, thermoelectrics, thermionics, photovoltaics, and magnetohydrodynamics. Prerequisites: ECE 340, 350.

438 Solar Energy. (3) S
Solar radiation and instrumentation, design and testing of collectors, performance analyses of systems, thermal storage, photovoltaics, materials, and economic analysis. Prerequisites: MAE 382, 388.

441 Design Theory and Techniques. (3) F, S
The design process, including problem definition, conceptual design, form and function, decision making, quality, material selection, manufacturability, modes of failure, fatigue, professionalism and ethics. Prerequisites: ECE 106, 313, 350.

442 Mechanical Systems Design. (3) F, S
Application of design principles and techniques to the synthesis, modeling, and optimization of mechanical, electromechanical, and hydraulic systems. Prerequisites: MAE 422 (or 425), 441.

443 Engineering Design. (3) F, S
Group projects to design engineering components and systems. Problem definition ideation, modeling, and analysis; decision making and documentation activities emphasized. 6 hours lab. Prerequisite: MAE 442 or 446.

446 Thermal Systems Design. (3) F
Application of engineering principles and techniques to the modeling and analysis of thermal systems and components. Optimization techniques are presented and their use demonstrated. Prerequisite: MAE 441.

447 Robotics and Its Influence on Design. (3) S
Robot applications, configurations, singular positions, and work space; modes of control; vision; programming exercises; design of parts for assembly. Prerequisite: MAE 317.

455 Polymers and Composites. (3) F
Relationship between chemistry, structure, and properties of engineering polymers. Design, properties, and behavior of fiber composite systems. Cross-listed as MSE 470. Prerequisite: ECE 350.

460 Gas Dynamics. (3) F, S
Compressible flow at subsonic and supersonic speeds; duct flow; normal and oblique shocks, perturbation theory, and wind tunnel design. Prerequisite: MAE 361 or 371.

461 Aerodynamics II. (3) F, S
Transonic/hypersonic flows, wing theory, Navier-Stokes, laminar/turbulent shear flows, pressure drop in tubes, separation, drag, viscous/inviscid interaction, and wing design. Prerequisite: MAE 460.

462 Dynamics of Flight. (3) F, S
Aerodynamic forces and moments, static stability and control, stability derivatives, and lateral and longitudinal motion and control. Aircraft design for longitudinal and lateral-directional stability with consideration of flying qualities. Lecture, design projects. Prerequisites: MAE 413, 467.

463 Propulsion. (3) F, S
Fundamentals of gas-turbine engines and design of components such as diffusers, compressors, turbines, combustors, and nozzles. Principles and design of rocket propulsion and alternative devices. Lecture, design projects. Pre- or corequisite: MAE 460.

464 Aerospace Laboratory. (2) F, S
Measurements of aerodynamic parameters in both subsonic and supersonic flows; flow over airfoils and bodies of revolution. Flow visualization. Computer-aided data acquisition and processing. Lecture, lab. Prerequisites: MAE 305, 460. Pre- or corequisite: MAE 461.

465 Rocket Propulsion. (3) S
Rocket flight performance; nozzle design; combustion of liquid and solid propellants; component design; advanced propulsion systems; interplanetary missions; testing. Prerequisite: MAE 460.

466 Rotary Wing Aerodynamics and Performance. (3) F, S
Introduction to helicopter and propeller analysis techniques. Momentum, blade-element, and vortex methods. Hover and forward flight. Ground effect, autorotation, and compressibility effects. Prerequisites: ECE 386; MAE 361 or instructor approval.

467 Aircraft Performance. (3) F, S
Integration of aerodynamic and propulsive forces into aircraft performance design. Estimation of drag parameters for conceptual design. Engine selection, airfoil selection. Introduction to aircraft conceptual design methodology. Lecture, design projects. Prerequisite: MAE 361. Pre- or corequisite: MAE 441.

468 Aerospace Systems Design. (3) F, S
Group projects related to aerospace vehicle design, working from mission definition and continuing through preliminary design; decision making and communication activities emphasized. Prerequisites: MAE 426, 441, 462.

471 Computational Fluid Dynamics. (3) F
Numerical solutions for selected problems in fluid mechanics. Prerequisite: MAE 372 or 461.

489 Thermophysics. (3) F
Basic principles of heat transfer and their application to aerospace systems; propulsion devices, spacecraft thermal control, and waste-heat rejection systems. Prerequisite: ECE 340.

490 Projects in Design and Development. (2) F, S
Capstone projects in fundamental or applied aspects of engineering. Prerequisites for Mechanical Engineering majors: MAE 441, 491. Prerequisite for Engineering Special Studies engineering mechanics majors: MAE 422.

491 Experimental Mechanical Engineering. (3) F, S
Experimental and analytical studies of phenomena and performance of fluid flow, heat transfer, thermodynamics, refrigeration, and mechanical power systems. 6 hours lab. Prerequisites: MAE 305, 372, 382, 388.

498 Pro-Seminar. (1–3) N
Special topics for advanced students. Application of the engineering disciplines to design and analysis of modern technical devices and systems. Prerequisite: instructor approval.

504 Laser Diagnostics. (3) S
Fundamentals of optics and the interaction of light with matter. Laser sources, laser spectroscopy, velocimetry, particle sizing, and surface characterization.

505 Perturbation Methods in Mechanics. (3) N
Nonlinear oscillations, strained coordinates, renormalization, multiple scales, boundary layers, matched asymptotic expansions, turning point problems, and WKBJ method.

506 Advanced System Modeling, Dynamics, and Control. (3) S
Lumped-parameter modeling of physical systems with examples. State variable representations and dynamic response. Introduction to modern control. Prerequisite: ASE 582 or MAT 442.

507 Optimal Control Theory and Application. (3) F
Optimal control of physical systems. Calculus of variations, Pontryagin's principle, minimum time/fuel problems, linear quadratic regulator, and numerical methods. Prerequisite: MAE 506.

508 Dynamics and Control of Aerospace Vehicles. (3) F
Dynamic modelling, guidance, and feedback control of atmospheric flight vehicles. Attitude dynamics and trajectory guidance, modal analysis, feedback compensation, single- and multi-loop systems. Prerequisites: MAE 462, 506.

509 Robust Multivariable Control. (3) S
Characterization of uncertainty in feedback systems, robustness analysis, synthesis techniques, multivariable Nyquist criteria, computer-aided analysis and design. Prerequisites: MAE 417, 506.

510 Dynamics and Vibrations. (3) F
Lagrange's and Hamilton's equations, rigid body dynamics, gyroscopic motion, and small oscillation theory.

511 Acoustics. (3) F
Principles underlying the generation, transmission, and reception of acoustic waves. Applications to noise control, architectural acoustics, random vibrations, and acoustic fatigue.

512 Random Vibrations. (3) S
Review of probability theory, random processes, stationarity, power spectrum, white noise process, random response of single and multiple DOF systems, and Markov processes simulation. Prerequisite: MAE 510 or instructor approval.

515 Structural Dynamics. (3) S
Free vibration and forced response of discrete and continuous systems, exact and approximate methods of solution, finite element modeling, and computational techniques. Prerequisite: MAE 510 or instructor approval.

517 Nonlinear Oscillations. (3) F
Existence, stability, and bifurcation of solutions of nonlinear dynamical systems. Methods of analysis of regular and chaotic responses. Prerequisite: MAE 510 or instructor approval.

518 Dynamics of Rotor-Bearing Systems. (3) S
Natural whirl frequency, critical speed, and response analysis of rigid and flexible rotor systems. Bearing influence and representation. Stability analysis. Methods of balancing.

520 Solid Mechanics. (3) F
Introduction to tensors: kinematics, kinetics, and constitutive assumptions leading to elastic, plastic, and viscoelastic behavior. Applications.

522 Variational Principles of Mechanics. (3) S
Virtual work, stationary, and complementary potential energies. Hamilton's principle. Application of these and direct methods to vibrations, elasticity, and stability. Prerequisite: MAE 520 or equivalent.

523 Theory of Plates and Shells. (3) F
Linear and nonlinear theories of plates. Membrane and bending theories of shells. Shells of revolution. Prerequisite: MAE 520.

524 Theory of Elasticity. (3) S
Formulation and solution of 2- and 3-dimensional boundary value problems. Prerequisite: MAE 520.

527 Finite Element Methods in Engineering Science. (3) F
Discretization, interpolation, elemental matrices, assembly, and computer implementation. Application to solid and fluid mechanics, heat transfer, and time dependent problems. Prerequisite: ASE 582.

529 Theory of Elastic Stability. (3) S
Stability of discrete and continuous mechanical systems. Stability of conservative and nonconservative systems. Dynamic instability. Prerequisite: MAE 523.

536 Combustion. (3) N
Thermodynamics; chemical kinetics of combustion. Explosion and ignition theories. Reactive gas dynamics. Structure, propagation, and stability of flames. Experimental methods. Prerequisite: MAE 436 or instructor approval.

537 Direct Energy Conversion. (3) N
Advanced selected topics in direct energy conversion, theory, design, and applications. Cross-listed as MSE 533. Prerequisite: MAE 581.

540 Advances in Engineering Design Theory. (3) F
Survey of research in engineering design process, artifact and design, knowledge, formal and informal logic, heuristic and numerical searches, theory of structure and complexity. Prerequisite: graduate standing.

541 CAD Tools for Engineers. (3) F
Elements of computer techniques required to develop CAD software. Data structures, including lists, trees, and graphs. Computer graphics, including 2- and 3-dimensional algorithms and user interface techniques.

542 Geometric Modeling in CAD/CAM. (3) S
Geometric and solid modeling, curve and surface design, CAD database architectures, and integration of solid modeling into engineering processes. Prerequisite: MAE 541 or instructor approval.

544 Mechanical Design and Failure Prevention. (3) F
Modes of mechanical failure; application of principles of elasticity and plasticity in multiaxial state of stress to design synthesis; failure theories; fatigue; creep; impact. Prerequisite: MAE 443.

546 CAD/CAM Applications in MAE. (3) F
Solution of engineering problems with the aid of state-of-the-art software tools in solid modeling, engineering analysis, and manufacturing; selection of modeling parameters; reliability tests on software. Open only to students without previous credit for MAE 406 or with instructor approval.

547 Mechanical Design and Control of Robots. (3) N
Homogeneous transformations, 3-dimensional kinematics, geometry of motion, forward and inverse kinematics, workspace and motion trajectories, dynamics, control, and static forces.

548 Mechanism Synthesis and Analysis. (3) S
Algebraic and graphical methods for exact and approximate synthesis of cam, gear, and linkage mechanisms; design optimization; methods of planar motion analysis; characteristics of plane motion; spatial kinematics.

557 Mechanics of Composite Materials. (3) S
Analysis of composite materials and applications. Micromechanical and macromechanical behavior. Classical lamination theory developed with investigation of bending-extension coupling.

560 Propulsion Systems. (3) N
Design of air-breathing gas turbine engines for aircraft propulsion; mission analysis; cycle analysis; engine sizing; component design.

561 Computational Aerodynamics. (3) S
Finite-difference and finite-volume techniques for solving the subsonic, transonic, and supersonic flow equations. The method of characteristics. Numerical grid generation techniques. Prerequisite: MAE 571 or instructor approval.

562 Transonic Flow. (3) F
Transonic flow, nonlinear small disturbance equations, and mixed flow with shock waves. Analytical and numerical treatments for airfoils. Applications to wings, bodies, and turbomachinery. Prerequisite: MAE 460 or 461.

563 Unsteady Aerodynamics. (3) S
Unsteady incompressible and compressible flow. Wings and bodies in oscillatory and transient motions. Kernel function approach and panel methods. Aeroelastic applications. Prerequisites: MAE 460 (or 461), 562.

564 Advanced Aerodynamics. (3) F
Perturbation method. Linearized subsonic and supersonic flows. Thin wing/slender body theories. Lifting surface theory. Panel method computation. Prerequisite: MAE 460 or 461.

565 Turbomachinery. (3) N
Design and performance of turbomachines, including turbines, compressors, pumps, fans, and blowers.

566 Rotary-Wing Aerodynamics. (3) F
Introduction to helicopter and propeller analysis techniques. Momentum, blade-element, and vortex methods. Hover and forward flight. Ground effect, autorotation, and copressiblilty effects. Prerequisite: MAE 361.

571 Fluid Mechanics. (3) F
Basic kinematic, dynamic, and thermodynamic equations of the fluid continuum and their application to basic fluid models.

572 Inviscid Fluid Flow. (3) S
Mechanics of fluids for flows in which the effects of viscosity may be ignored. Potential flow theory, waves, and inviscid compressible flows. Prerequisite: MAE 571.

573 Viscous Fluid Flow. (3) F
Mechanics of fluids for flows in which the effects of viscosity are significant. Exact and approximate solutions of the Navier-Stokes system, laminar flow at low and high Reynolds number. Prerequisite: MAE 571.

574 Viscous, Compressible Fluid Flow. (3) N
Mechanics of fluids for flows in which the effects of compressibility and viscosity are significant. Compressible boundary layers, free shear layers, shock waves, and internal flows. Prerequisite: MAE 572.

575 Turbulent Shear Flows. (3) F
Homogeneous, isotropic, and wall turbulence. Experimental results. Introduction to turbulent-flow calculations. Prerequisite: MAE 571.

577 Turbulent Flow Modeling. (3) S
Reynolds equations and their closure. Modeling of simple and complex turbulent flows, calculations of internal and external flows, and application to engineering problems. Prerequisite: MAE 571.

581 Thermodynamics. (3) F
Basic concepts and laws of classical equilibrium thermodynamics. Applications to engineering systems.

582 Statistical Thermodynamics. (3) N
Kinetic and quantum theory. Statistical mechanics; ensemble theory. Structure and thermodynamics of non-interacting and interacting particles. Boltzmann integro-differential equation. Cross-listed as MSE 531. Prerequisite: MAE 581.

585 Conduction Heat Transfer. (3) F
Basic equations and concepts of conduction heat transfer. Mathematical formulation and solution (analytical and numerical) of steady and unsteady, one- and multidimensional heat conduction and phase change problems. Prerequisites: ECE 386; MAE 388.

586 Convection Heat Transfer. (3) S
Basic concepts and governing equations. Analysis of laminar and turbulent heat transfer for internal and external flows. Natural and mixed convection. Prerequisite: MAE 388.

587 Radiation Heat Transfer. (3) F
Advanced concepts and solution methodologies for radiation heat transfer, including exchange of thermal radiation between surfaces, radiation in absorbing, emitting, and scattering media and radiation combined with conduction and convection. Prerequisite: MAE 388.

588 Two-Phase Flows and Boiling Heat Transfer. (3) S
Pool and flow boiling heat transfer, condensation heat transfer, various models of vapor-liquid mixture flows, gas-solid mixture flows, and experimental measurement techniques.

589 Heat Transfer. (3) F
Basic concepts; physical and mathematical models for heat transfer. Applications to conductive, convective, radiative, and combined mode heat transfer. Prerequisite: MAE 388.

594 Graduate Research Conference. (1) F, S
Topics in contemporary research. Required every semester of all departmental graduate students registered for 9 or more semester hours. Not for degree credit.

598 Special Topics. (1–3) F, S
Special topics courses, including the following, which are regularly offered, are open to qualified students:
(a) Boundary Layer Stability
(b) Polymers and Composites
(c) Hydrodynamic Stability
(d) Advanced Spacecraft Control
(e) Plasticity
(f) Aeroelasticity
(g) Aerospace Vehicle Guidance and Control

Omnibus Courses: See page 44 for omnibus courses that may be offered.

Programs in Engineering Special and Interdisciplinary Studies

Daniel F. Jankowski
Director

The degree programs described in the “Programs in Engineering Special and Interdisciplinary Studies” table on page 278 are administered by the Office of the Dean of the College of Engineering and Applied Sciences.

Descriptions of these majors and options, with their respective program requirements, can be found on the pages indicated in the table.

PURPOSE

The majors of Engineering Special Studies and of Engineering Interdisciplinary Studies accommodate students whose educational objectives require more intensity of concentration on a particular subject or more curricular flexibility within an engineering discipline than the traditional departmental majors generally permit. These majors are School of Engineering programs. Unlike the departmental major areas, however, there is not a separate faculty. The faculty teaching and advising in these programs are from the School of Engineering.

For many students, engineering studies form the basis of preparation for professional engineering work where proficiency in the application of science and the physical and social technologies is brought to bear on problems of a large scope. The necessary breadth that these students seek often is not obtainable in traditional engineering fields. Rather, specially designed programs of course work that merge the required principles and approaches drawn from all fields of engineering and other pertinent disciplines are desired. As an answer to this need, two types of course arrangements are available: (1) the Bachelor of Science in Engineering (B.S.E.) degree with a major in Engineering Special Studies and (2) the Bachelor of Science (B.S.) degree with a major in Engineering Interdisciplinary Studies.

Programs in Engineering Special and Interdisciplinary Studies

Degree	Major	Option	Description
B.S.E.	Engineering Special Studies	Engineering Mechanics	Pages 278–279
		Manufacturing Engineering	Page 269
		Pre-medical Engineering	Pages 279–280
B.S.	Engineering Interdisciplinary Studies	Geological Engineering	Pages 280

The B.S.E. in Engineering Special Studies is designed primarily for students intending to pursue engineering careers at a professional level in industry or graduate studies. The B.S. in Engineering Interdisciplinary Studies accommodates those students who desire the integrity of an engineering education but who plan to enter professions other than engineering or particularly to serve society in socially relevant activities. Both are developed beyond the general studies and the engineering core.

The curricula leading to both the B.S.E. and the B.S. degrees have been accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (ABET).

ENGINEERING SPECIAL STUDIES—B.S.E.

Engineering Mechanics. The curriculum of the engineering mechanics option is intended for individuals interested in pursuing a more basic and theoretical education than is provided by typical curricula in aerospace, civil, or mechanical engineering. This curriculum is particularly suited for individuals whose goals are an increased depth of understanding in the fundamentals of mechanics and the pursuit of an advanced engineering degree, with the ultimate career goal of an academic or research position. Thus, it is strongly recommended that a GPA of at least 3.00 be maintained by all engineering mechanics students.

The engineering mechanics option is based on increased course work in mathematics and the broad field of engineering mechanics, the latter of which includes three interrelated areas: dynamics, fluid mechanics, and solid mechanics. Each of these areas is related to a variety of important and challenging technological problems. Examples include vibration control in space vehicles at launch, optimal design of composite structures, crystal growing in a microgravity environment, fluid transition to turbulence on swept wings, and computer-aided modeling of structures ranging from surgical implants to space satellites. The fundamental emphasis of the engineering mechanics program provides the flexibility and understanding that is required to cope with rapidly occurring changes in technology and the needs of society.

This option is administered by the Department of Mechanical and Aerospace Engineering.

Refer to page 244, engineering core section. No course may be deleted and engineering mechanics students are required to select the following electives in the engineering core:

			Semester Hours
ECE	384	Numerical Analysis for Engineers I	2
ECE	386	Partial Differential Equations for Engineers	2
MAE	305	Measurements and Microcomputers	4
PHY	361	Introductory Modern Physics[1]	3

In addition, the following courses are required:

			Semester Hours
MAE	371	Fluid Mechanics	3
MAE	372	Fluid Mechanics	4
MAE	388	Heat Transfer	3
MAE	402	Introduction to Continuum Mechanics	3
MAE	404	Finite Elements in Engineering	3
MAE	413	Spacecraft Dynamics and Control	3
MAE	415	Vibration Analysis	4
MAE	422	Mechanics of Materials	4
MAE	441	Design Theory and Techniques	3
MAE	490	Projects in Design and Development	2
MAT	342	Linear Algebra	3
MAT	371	Advanced Calculus I or MAT 460 Applied Real Analysis (3)	3
MSE	440	Mechanical Properties of Solids	3
Technical electives[2]			6–7
Total			47–48

[1] Basic science elective.
[2] Must include two courses of engineering design-type content.

Technical electives may be selected from one or more of the following areas. A student may, with prior approval, select a general area or a set of courses that would support a career objective not covered by the following categories.

Biomechanics. BME 411, 412, 416, 419; EEE 434; MAE 341.

Dynamics. MAE 462, 505, 510, 511, 512, 515, 517, 518.

Engineering Mathematics. ASE 485, 582, 586; ECE 383, 385; MAT 371, 460, 461, 462; STP 421.

Fluid Mechanics. MAE 435, 460, 463, 471, 571.

Solid Mechanics. MAE 426, 520, 522, 523, 524, 529.

Engineering Mechanics Program of Study Typical Last Two-Year Sequence

Junior Year

First Semester			Semester Hours
ECE	333	Electrical Instrumentation or ECE 334 Electronic Devices and Instrumentation (4)	3
MAE	371	Fluid Mechanics	3
MAT	371	Advanced Calculus I or MAT 460 Applied Real Analysis (3)	3
MSE	440	Mechanical Properties of Solids	3
PHY	361	Introductory Modern Physics	3
HU or SB elective*			3
Total			18

Second Semester			
ECE	384	Numerical Analysis for Engineers I	2
MAE	305	Measurements and Microcomputers	4
MAE	372	Fluid Mechanics	4

MAE	413	Spacecraft Dynamics and Control	3
MAE	422	Mechanics of Materials	4
Total			17

Senior Year

First Semester

MAE	388	Heat Transfer	3
MAE	402	Introduction to Continuum Mechanics	3
MAE	404	Finite Elements in Engineering	3
MAE	415	Vibration Analysis	4
MAE	441	Design Theory and Techniques	3
Total			16

Second Semester

ECE	400	Engineering Communications	3
MAE	490	Projects in Design and Development	2
HU or SB elective*			3
Technical electives			7
Total			15

* See pages 53–71 for the requirements and the approved list.

Manufacturing Engineering. This option is administered by the Department of Industrial and Management Systems Engineering (see page 269).

Pre-medical Engineering. In the past decade, the interrelation between engineering and medicine has become vigorous and exciting. Our rapidly expanding technology dictates that engineering will continue to become increasingly involved in all branches of medicine. As this develops, so will the need for physicians trained in the engineering sciences—medical men and women with a knowledge of computer technology, transport phenomena, biomechanics, bioelectric phenomena, operations research, and cybernetics. This option is of special interest to students desiring entry into a medical college and whose medical interests lie in research, aerospace and undersea medicine, artificial organs, prostheses, biomedical engineering, or biophysics. Since both engineering and medicine have as their goal the well-being of humans, this program is compatible with any field of medical endeavor.

Academic Requirements. In addition to the general studies requirements, BIO 181 General Biology (basic science elective) and CHM 116 General Chemistry must be selected in the engineering core. Refer to page 240, engineering core section. Other engineering core requirements are outlined in the area of emphasis descriptions. The following courses are required in the premedical engineering option and have been selected to meet all university and ABET accreditation requirements:

			Semester Hours
AGB/BME	435	Animal Physiology I	4
BIO	182	General Biology	4
BME	331	Transport Phenomena I: Fluids	3
BME	334	Heat and Mass Transfer	3
BME	411	Biomedical Engineering I or BME 412 Biomedical Engineering II (3)	3
BME	413	Physiological Instrumentation	3
BME	417	Biomedical Engineering Design	3
BME	423	Physiological Instrumentation Laboratory	1
BME	490	Biomedical Engineering Projects	2
BME	496	Professional Seminar[1]	0
CHM	113	General Chemistry	4
CHM	331	General Organic Chemistry	3
CHM	332	General Organic Chemistry	3
CHM	335	General Organic Chemistry Laboratory	1
CHM	336	General Organic Chemistry Laboratory	1
Engineering technical electives[2]			13
Total			51

[1] Students must register for BME 496 each semester.

[2] To be selected from an area of emphasis and must include one course of engineering design type content.

Students interested in pre-medical engineering may choose either computer science or general bioengineering as an area of emphasis.

Computer Science. This emphasis is designed for students interested in the application of modern computer technology for medical information processing and medical scientific computation and for the recognition, storage, retrieval, and processing of medical data. The following courses are required in the engineering core: BME 470, ECE 333, 340, and 352, and MAT 242. ECE 312 is not required in the engineering core. Technical electives must include CSE 310, one advanced computer programming course selected from CSE 383 or 470, and upper-division engineering courses of engineering science and design content.

General Bioengineering. This emphasis is designed to strengthen the student's knowledge of bioengineering. It emphasizes biomedical research. The following courses are required in the engineering core: ECE 340 and 350 and MAE 305. ECE 312 is not required in the engineering core. The technical electives may be selected from engineering, biology, or chemistry upper-division courses, but these courses must include adequate engineering science and design content.

Pre-medical Engineering Program of Study Typical Four-Year Sequence

First Year

First Semester

			Semester Hours
BME	496	Professional Seminar	0
CHM	113	General Chemistry	4
ECE	105	Introduction to Languages of Engineering	3
ECN	111	Macroeconomic Principles	3
ENG	101	First-Year Composition	3
MAT	290	Calculus I	5
Total			18

Second Semester

BME	496	Professional Seminar	0
CHM	116	General Chemistry	4
ECE	106	Introduction to Computer-Aided Engineering	3
ENG	102	First-Year Composition	3
MAT	291	Calculus II	5
PHY	121	University Physics I: Mechanics	3
PHY	122	University Physics Laboratory I	1
Total			19

Second Year

First Semester

BIO	181	General Biology	4
BME	496	Professional Seminar	0
MAT	274	Elementary Differential Equations	3
PHY	131	University Physics II: Electricity and Magnetism	3
PHY	132	University Physics Laboratory II	1
L1 elective*			3
Total			14

Second Semester

BIO	182	General Biology	4
BME	496	Professional Seminar	0
CHM	331	General Organic Chemistry	3
CHM	335	General Organic Chemistry Laboratory	1
ECE	210	Engineering Mechanics I: Statics	3
ECE	301	Electrical Networks I	4
HU or SB elective*			3
Total			18

Third Year

First Semester

BME	331	Transport Phenomena I: Fluids	3
BME	435	Animal Physiology I	4
BME	496	Professional Seminar	0
CHM	332	General Organic Chemistry	3
ECE	313	Introduction to Deformable Solids	3
ECE	340	Thermodynamics or CHM 441 General Physical Chemistry (3)	3
ECE	350	Structure and Properties of Materials or CHM 442 General Physical Chemistry (3) or ECE 351 Engineering Materials (3) or ECE 352 Properties of Electronic Materials (3)	3
Total			19

Second Semester

BME	334	Heat and Mass Transfer	3
BME	496	Professional Seminar	0
CHM	336	General Organic Chemistry Laboratory	1
ECE	333	Electrical Instrumentation or ECE 334 Electronic Devices and Instrumentation(4)	3
ECE	384	Numerical Analysis for Engineers I or ECE 386 Partial Differential Equations for Engineers (2) or MAT 242 Elementary Linear Algebra (2)	2
HU or SB elective*			3
Technical elective			6
Total			18

Fourth Year

First Semester

BME	411	Biomedical Engineering I or BME 412 Biomedical Engineering II (3)	3
BME	413	Physiological Instrumentation	3
BME	423	Physiological Instrumentation Laboratory	1
BME	490	Biomedical Engineering Projects	2
BME	496	Professional Seminar	0
HU or SB elective*			3
Technical elective			4
Total			16

Second Semester

BME	417	Biomedical Engineering Design	3
BME	470	Microcomputer Applications in Bioengineering	3
BME	496	Professional Seminar	0
ECE	383	Probability and Statistics for Engineers	2
ECE	400	Engineering Communications	3
HU or SB elective*			3
Technical elective			3
Total			17

Degree requirements: 133 semester hours plus English proficiency.

* See pages 53–71 for the requirements and the approved list of courses.

ENGINEERING INTERDISCIPLINARY STUDIES—B.S.

Geological Engineering. This option incorporates the joint application of engineering and geological principles to the planning, analysis, and design of engineering projects directly related to the earth, its materials, structures, and forces. The goal of the program is to investigate the physical properties of the shallow portions of the earth's crust that influence the design and construction of engineering structures such as foundations, excavations, dams, highways, and sites for waste disposal. Additionally, the geological factors associated with land use planning and with the development of water, petroleum, and mineral deposits are encompassed within the program.

Refer to page 240, engineering core section. The following courses are required as a part of the engineering core (only ECE 333 Electronic Instrumentation may be deleted):

			Semester Hours
CEE	400	Microcomputer Applications in Civil Engineering	3
ECE	210	Engineering Mechanics I: Statics	3
ECE	312	Engineering Mechanics II: Dynamics	3
ECE	351	Engineering Materials	3
GLG	101	Introduction to Geology I (Physical)[1]	3

In addition, the following courses are required in the major:

			Semester Hours
CEE	351	Soil Mechanics	4
CEE	452	Foundations	3
CEE	552	Geological Engineering	3
CEE	556	Seepage and Earth Dams	3
GLG	103	Introduction to Geology I–Laboratory	1
GLG	310	Structural Geology	3
GLG	321	Mineralogy	3
GLG	322	Mineralogy Laboratory	2
GLG	362	Geomorphology	3
GLG	424	Petrology-Petrography	4
MAE	371	Fluid Mechanics	3
Engineering technical electives[2]			20
Total			52

[1] Basic science elective.

[2] Must include two courses of engineering science and three courses of engineering design type content. An approved summer engineering-geology field course is also highly recommended.

School of Technology

Albert L. McHenry
Director
(TC 201A) 602/965–3874

PURPOSE

The primary purpose of the school is to provide students the opportunity to obtain a quality education in technology and to qualify them directly for positions of leadership and responsibility in industrial, commercial, educational, and government activity.

The technology programs provide the opportunity to earn a degree that stresses theory reinforced by laboratory application—a more applied approach than engineering students experience. The technology programs assist in preparing for challenging career opportunities in industry and government for the forward-looking student. The technology graduate in industry becomes a member of the total engineering effort, contributing an applications orientation to complement the engineer's more theoretical concepts. The student is educated to render practical decisions with safety and economy in mind, to install and operate technical systems, to develop or improve a product, to revise systems, and to provide customer support when needed.

DEGREES

Bachelor of Science degree programs and options within each major are offered in the three departments as shown on pages 225–226. Each curriculum includes some elective courses that are reserved for the student's use to add a unique emphasis or dimension. These credits are traditionally referred to as technical electives and are normally restricted to upper-division courses in technology, engineering, and computer science. In each case, the choice of technical electives must be approved by the student's faculty advisor and department chair. Requirements for each of the majors offered are described on the following pages.

In addition to the undergraduate degrees offered in the School of Technology, the Master of Technology degree (M.Tech.) is offered by each of the three departments in technology in accordance with the details given on page 228. See the *Graduate Catalog* for complete details.

ADMISSION

See pages 31–35, 48–49, 224–225, and 230 for information regarding requirements for admission, transfer, retention, disqualification, and reinstatement.

A preprofessional category is available for applicants deficient in regular admission requirements.

Entry into a program in one of the departments of technology as a freshman student requires three years of high school math (algebra I and II and geometry). High school chemistry and physics are recommended. Students without the required math background must take appropriate deficiency courses before entry or immediately upon enrollment at ASU. Associate degree transfer students are expected to have completed college algebra and trigonometry.

Students who begin their college education at institutions other than ASU with intent to transfer to ASU should consult the given major requirements and seek equivalent courses at the transfer institution. Any transfer courses from a community college are applied only as lower-division credit.

The GPA requirement for admission of transfer students into the School of Technology is 2.25 for Arizona residents and 2.50 for nonresidents. The freshman and sophomore programs of study are designed to facilitate transfer of junior and community college students or associate degree graduates.

In addition, international students are required to have a TOEFL score of 500 for admission to a technology major.

DEGREE REQUIREMENTS

All baccalaureate degree programs in the School of Technology require completion of the university English proficiency requirement, a general studies component, and a technology core component. The engineering technology programs also require completion of an engineering technology core. All programs require a minimum of 132 semester hours.

The specific course requirements for the English proficiency, general studies, technology core, and the engineering technology core are listed below. Refer to the individual majors or options for their additional required courses.

English Proficiency			*Semester Hours*
ENG	101, 102	First-Year Composition[1] or ENG 105 Advanced First-Year Composition (3)	6
General Studies			
Literacy and Critical Inquiry[2]			
One L1 course			3
ETC	400	Technical Communications[1]	3
Numeracy			
ECE	106	Introduction to Computer-Aided Engineering[1]	3
MAT	170	Precalculus[1]	3
Humanities and Fine Arts and Social and Behavioral Sciences[2] (15 semester hours minimum) At least one course must be of upper-division level, two courses must be from the same department, and two or more departments must be represented in total selection.			
HU course(s)			6–9
SB course(s)			3–6
ECN	111	Macroeconomic Principles[1]	3
Natural Sciences			
PHY	111	General Physics[1]	3
PHY	112	General Physics[1]	3
PHY	113	General Physics Laboratory[1]	1
PHY	114	General Physics Laboratory[1]	1
Total general studies			35

NOTE: Six semester hours taken in two of the three awareness areas[2] are required in the final list of courses offered in the student's graduation program of study. These can be included in the HU and SB course selections. See the list of acceptable courses.

[1] Graduation requirement for the baccalaureate degree.

[2] See pages 53–71 for the requirements and the approved list.

Technology Core

The following courses constitute the Technology Core and are required in all baccalaureate degree programs in the School. These courses, with the exception of ECE 105, also satisfy part of the general studies component. Refer to the individual department descriptive material for specific departmental degree requirements.

			Semester Hours
ECE	105	Introduction to Languages of Engineering	3
ECE	106	Introduction to Computer-Aided Engineering	3
ECN	111	Macroeconomics Principles	3
ETC	400	Technical Communications	3
PHY	111	General Physics	3
PHY	112	General Physics	3
PHY	113	General Physics Laboratory	1
PHY	114	General Physics Laboratory	1
Total			20

Engineering Technology Core

The following courses constitute the engineering technology core and are required in all baccalaureate degree programs in the engineering technologies:

			Semester Hours
CHM	101	Introductory Chemistry or CHM 113 General Chemistry (4) or CHM 114 General Chemistry for Engineers (4)	4
ETC	201	Applied Electrical Science	4
ETC	211	Applied Engineering Mechanics: Statics	3
ETC	340	Applied Thermodynamics and Heat Transfer	3
MAT	260	Technical Calculus I	3
MAT	261	Technical Calculus II	3
Total			20

GRADUATION REQUIREMENTS

In order to qualify for graduation from the School of Technology, a student must have an overall GPA of at least 2.00 and a GPA of at least 2.00 for the required courses in the major field.

PROFESSIONAL ACCREDITATION AND AFFILIATIONS

The undergraduate programs in Aeronautical Engineering Technology, Electronics Engineering Technology, and Manufacturing Engineering Technology are accredited by the Technology Accreditation Commission of the Accreditation Board for Engineering and Technology.

SPECIAL PROGRAMS

ASU 2+2 Programs. The School of Technology maintains a cooperative agreement with most community colleges within Arizona and also with selected out-of-state colleges and universities to structure courses that are directly transferable into the technology programs at ASU.

ENGINEERING TECHNOLOGY CORE

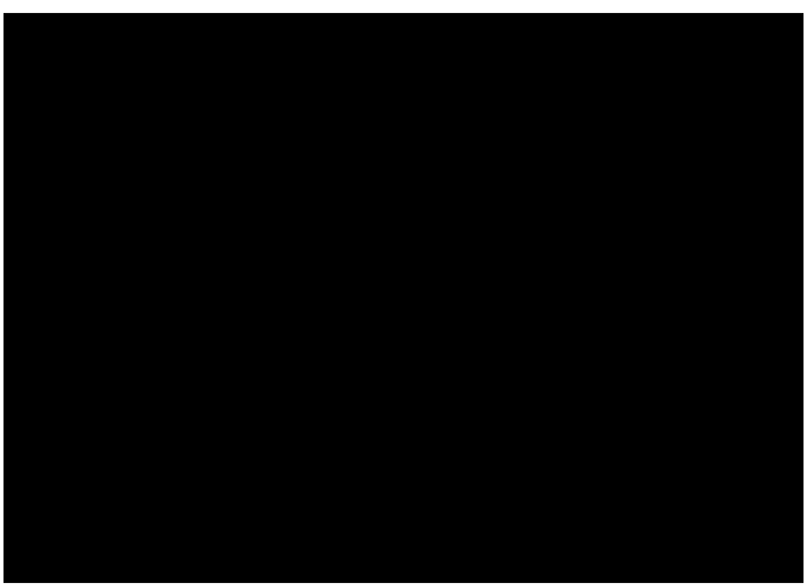
ETC 201 Applied Electrical Science. (4) F, S, SS
Principles of electricity, passive elements, and d-c and a-c circuit analysis. Laboratory exploration of circuit concepts and techniques using instrumentation and the computer as a tool. Lecture, lab. Prerequisites: ECE 105; MAT 170.

211 Applied Engineering Mechanics: Statics. (3) F, S, SS
Vectors, forces and moments, force systems, equilibrium, analysis of basic structures and structural components, friction, centroids, and moments of inertia. Cross-listed as CON 221. Prerequisites: MAT 261 or equivalent; PHY 111, 113.

340 Applied Thermodynamics and Heat Transfer. (3) F, S
Thermodynamic systems and processes, first and second laws of thermodynamics, properties of pure substances, and applications to heat engines and special systems. Fundamentals of conduction, radiation, and convection. Prerequisites: MAT 261; PHY 112, 114.

400 Technical Communications. (3) F, S, SS
Planning and preparing technical publications and oral presentations based on directed library research related to current technical topics. Prerequisites: senior standing as a CEAS major; completion of first-year English requirements; L1 course. *General studies: L2.*

Omnibus Courses: See page 44 for omnibus courses that may be offered.



Aeronautical Technology

Robert O. Meitz
Chair
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PROFESSOR
GESELL

ASSOCIATE PROFESSORS
MEITZ, REED

ASSISTANT PROFESSOR
STANFORD

LECTURERS
ALJABARI, HOMAN, SCHLAFMAN

VISITING ASSISTANT PROFESSORS
KELLY, ROGERS

PROFESSORS EMERITI
CARLSEN, COX, MATTHEWS, PEARCE, ROPER, SALMIRS, SCHOEN, THOMASON

The Department of Aeronautical Technology offers two majors leading to a Bachelor of Science degree. The majors are Aeronautical Engineering Technology and Aeronautical Management Technology. The Aeronautical Management Technology major includes options in airway science aircraft systems management, airway science management, and *ab initio* airline pilot flight management.

Graduates are prepared for entry into the aerospace industry in productive, professional employment or, alternatively, for graduate study. The curricula emphasize the recognized principles underlying the application of technical knowledge as well as current technology, preparing the graduate to adapt to the rapid and continual changes in aerospace technology.

Admission

New and transfer students who have been admitted to the university, who meet the requirements for admission to the School of Technology, and who have selected Aeronautical Technology are admitted to Aeronautical Technology without separate application to the Department of Aeronautical Technology. Transfer credits are reviewed by department faculty advisors. To be admissible to department curricula, transfer courses must be equivalent in both content and level of offering.

Identified Lower-Division Courses

The 50 semester hours of *identified lower-division courses,* listed below, must be completed satisfactorily before any upper-division courses other than ENG 301 may be taken. Each of the *identified lower-division courses* must be completed with a grade of C or better.

Identified Lower-Division Courses

AET	182	Private Pilot Ground School	3
AET	280	Aeronautical Structures and Materials	4
AET	287	Aeronautical Powerplants	4
CHM	114	General Chemistry for Engineers	4
CSE	181	Applied Problem Solving With BASIC	3
		or CSE 183 Applied Problem Solving With FORTRAN (3)	
ECE	105	Introduction to Languages of Engineering	3
ECE	106	Introduction to Computer Aided Engineering	3
ECN	111	Macroeconomic Principles	3
ENG	101	First-Year Composition	3
ENG	102	First-Year Composition	3
MAT	170	Precalculus Algebra	3
MAT	260	Technical Calculus I	3
PGS	101	Introduction to Psychology	3
PHY	111	General Physics	3
PHY	112	General Physics	3
PHY	113	General Physics Laboratory	1
PHY	114	General Physics Laboratory	1
Total			50

AERONAUTICAL ENGINEERING TECHNOLOGY—B.S.

The Aeronautical Engineering Technology degree program is accredited by the Technology Accreditation Commission of the Accreditation Board for Engineering and Technology. The curriculum is designed to prepare the graduate for professional-level technical support of engineering activities throughout the aerospace field. Areas of responsibility include the application of applied engineering practice related to aircraft and aerospace vehicle design, internal combustion engines, combustion processes, turbomachinery, systems analysis, computer modeling, quality assurance and nondestructive testing, and wind tunnel applications.

Aeronautical Engineering Technology students are required to complete a minimum of 132 semester hours, including at least 50 semester hours of upper-division courses. All degree requirements are shown on the student's Curriculum Check Sheet. These requirements include English proficiency, general studies, technology core, engineering technology core, and specific additional courses listed in the following section.

Degree Requirements

In addition to the required courses listed for English proficiency, general studies, technology core, and the engineering technology core (see page 223), the following additional courses are required: AET 182, 280, 287, 300, 310, 312, 320, 394, 409, 415, 417, 487, 494; CHM 114; CSE 183; EET 205; ENG 301; MAT 262; MET 230, 313, 432; STP 420; three elective hours.

Suggested Course Pattern for Freshmen

First Semester			Semester Hours
CHM	114	General Chemistry for Engineers	4
ECN	111	Macroeconomic Principles	3
ENG	101	First-Year Composition	3
MAT	170	Precalculus Algebra	3
PHY	111	General Physics	3
PHY	113	General Physics Laboratory	1
Total			17
Second Semester			
AET	182	Private Pilot Ground School	3
ECE	105	Introduction to Languages of Engineering	3
ENG	102	First-Year Composition	3
MAT	260	Technical Calculus I	3
PHY	112	General Physics	3
PHY	114	General Physics Laboratory	1
Total			16

AERONAUTICAL MANAGEMENT TECHNOLOGY—B.S.

The Aeronautical Management Technology curriculum is designed to provide a thorough technical background combined with an interdisciplinary general university education. The graduate is prepared to assume responsibilities in a wide area of managerial and technically related areas of aviation. The student gains a background in aircraft structures, reciprocating and turbine engines, performance, design, management skills, business principles, systems analysis, and a variety of course work specific to aircraft flight, airport operations, and air transportation systems. The degree offers three options: *ab initio* airline pilot flight management, airway science management, and airway science aircraft systems management. Airway science management and airway science aircraft systems management curricula have the approval of the Federal Aviation Administration as airway science programs and can lead to employment in that agency. The three options are described separately below.

Ab Initio Airline Pilot Flight Management Option

Flight training is certified by the Federal Aviation Administration.

Ab initio airline pilot flight management combines academic studies and flight training to prepare graduates for positions within the air transportation industry, primarily in the area of flight operations. Theoretical preparation and flight training are specifically intended to prepare the student for employment in the scheduled airline industry.

This curriculum concentrates on flying plus the technical, management, and computer-related applications necessary to operate in the high-density environment of modern airspace. The program emphasizes critical thinking and cognitive, analytical, and communication skills. The career option leads to airline piloting and the development, administration, and enforcement of safety regulations including airworthiness and operational standards in civil aviation.

Ground schools and flight training in the *ab initio* airline pilot flight management option are tightly integrated and highly organized as a single, continuous training program. Each student begins actual flight training at the beginning of the flight training syllabus and complete each lesson block in sequence, throughout the training. Flight experience and certificates received before enrollment at ASU may or may not allow the individual student to progress more easily through the training, but in any case, is not used to replace training requirements in the ASU program.

While enrolled at ASU, students do not receive college credit for flight instruction received at flight schools other than schools under contract with the university for *ab initio* flight instruction.

Flight instruction costs are not included in university tuition. The estimated cost of ab initio flight training is $55,000 in addition to normal university costs.

Ab initio airline pilot flight management students are required to complete a minimum of 132 semester hours, including at least 50 semester hours of upper-division courses. Students in the *ab initio* airline pilot flight management option must also successfully complete qualification screening examinations before beginning *ab initio* flight training. Qualification screening includes a first-class medical examination, psychological evaluation, and a psychomotor skills tests. Students who do not pass the qualification screening examinations but are otherwise qualified may continue in Aeronautical Engineering Technology or in Aeronautical Management Technology, in either the airway science management option or the airway science aircraft systems management option.

All degree requirements are shown on the student's curriculum check sheet. These requirements include English proficiency, general studies, the technology core, and specific additional courses listed in the following section.

Degree Requirements

In addition to the required courses listed for English proficiency, general studies, and the technology core (see page 223), the following additional courses are required: AET 182, 185, 186, 224, 285, 286, 287, 300, 308, 342, 362, 363, 364, 365, 394, 410, 487, 494; CHM 114; COM 225 or ENG 301; CSE 181 or 183 or 201; ETC 201, 211; HIS 414; IST 346, 452; MAT 260, 261; MET 230 or CET 250; PGS 101; STP 420; three elective hours.

Suggested Course Pattern for Freshmen

First Semester			Semester Hours
CHM	114	General Chemistry for Engineers	4
ECN	111	Macroeconomic Principles	3
ENG	101	First-Year Composition	3
MAT	170	Precalculus Algebra	3
PHY	111	General Physics	3
PHY	113	General Physics Laboratory	1
Total			17

Second Semester			
AET	182	Private Pilot Ground School	3
ECE	105	Introduction to Languages of Engineering	3
ENG	102	First-Year Composition	3
MAT	260	Technical Calculus I	3
PHY	112	General Physics	3
PHY	114	General Physics Laboratory	1
Total			16

Ab initio airline pilot flight training is available through the College of Extended Education for individuals who have completed a degree not necessarily associated with an aviation career. Individuals desiring to participate in this training must successfully complete qualification screening examinations before beginning *ab initio* flight training. Depending on individual background, it may be necessary to make up academic deficiencies before beginning the theoretical preparation courses and flight courses that make up *ab initio* airline pilot flight training. Completion of training through this method results in the award of a certificate of completion. No degree is awarded.

Airway Science Aircraft Systems Management Option

Flight training is certified by the Federal Aviation Administration.

Airway science aircraft systems management combines academic studies and flight training to prepare graduates for a wide variety of positions within the air transportation industry, primarily within the area of general aviation flight operations. Ground school and flight training are available, allowing the student to obtain private pilot, commercial pilot, and flight instructor certificates and also the instrument pilot, instrument instructor, and multiengine pilot ratings.

This curriculum concentrates on flying plus the technical, management, and computer-related applications necessary to operate in the high-density environment of modern airspace. This career leads to the development, administration, and enforcement of safety regulations, including airworthiness and operational standards in civil aviation. The program emphasizes critical thinking, and cognitive, analytical, and communication skills. The airway science aircraft systems management option is approved by the Federal Aviation Administration as an Airway Science Program.

While enrolled at ASU, students do not receive college credit for flight activity or instruction received at flight schools other than schools with which the university has currently contracted for such instruction. Consideration is given for flight experience received before enrollment at the university. *Flight instruction costs are not included in university tuition. The estimated cost of flight training is $30,000 in addition to normal university costs.*

Airway science flight systems management students are required to complete a minimum of 132 semester hours, including at least 50 semester hours of upper-division courses. All degree requirements are shown on the student's Curriculum Check Sheet. These requirements include English proficiency, general studies, the technology core, and specific additional courses listed in the following section.

Degree Requirements

In addition to the required courses listed for English proficiency, general studies, and the technology core (see page 223), the following additional courses are required: AET 182, 183, 220, 222, 280, 287, 300, 308, 314, 342, 344, 382, 383, 385, 386, 387, 389, 391, 392, 393, 395, 408, 410, 489; CHM 114; COM 225 or ENG 301; CSE 181 or 183 or 201; ECE 105; ETC 211; HIS 414; IST 346, 452; MAT 260, 261; MET 230 or CET 250; PGS 101; STP 420; three elective hours.

Suggested Course Pattern for Freshmen

First Semester			Semester Hours
CHM	114	General Chemistry for Engineers	4
ECN	111	Macroeconomic Principles	3
ENG	101	First-Year Composition	3
MAT	170	Precalculus Algebra	3
PHY	111	General Physics	3
PHY	113	General Physics Laboratory	1
Total			17

Second Semester			
AET	182	Private Pilot Ground School	3
ECE	105	Introduction to Languages of Engineering	3
ENG	102	First-Year Composition	3
MAT	260	Technical Calculus I	3
PHY	112	General Physics	3
PHY	114	General Physics Laboratory	1
Total			16

Airway Science Management Option

The airway science management option is designed to prepare graduates for managerial and supervisory positions throughout the air transportation industry. A depth of technical training is included along with a broad exposure to business and management courses. This program of study, interdisciplinary in nature, prepares the aeronautical career-oriented student for such positions as air traffic control specialist, air carrier manager, airport manager, and general aviation operations manager.

Airway science management students are required to complete a minimum of 132 semester hours, including at least 50 semester hours of upper-division courses. All degree requirements are shown on the student's Curriculum Check Sheet. These requirements include English proficiency, general studies, the technology core, and specific additional courses listed in the following section.

Degree Requirements

In addition to the required courses listed for English proficiency, general studies, and the technology core (see page 223), the following additional courses are required: ACC 230; AET 182, 201, 280, 287, 308, 342, 344, 408, 410, 489; CHM 114; COM 225; CSE 181 or 183 or 201; ECN 112; ETC 201; HIS 414; IEE 431; IST 346 or MGT 301, 452 or MGT 311, 480 or MGT 352, 491 or MGT 423, 498 or LES 305; MAT 260; MET 230 or CET 250; PGS 101; SOC 301; STP 420; nine elective hours.

Suggested Course Pattern for Freshmen

First Semester			Semester Hours
CHM	114	General Chemistry for Engineers	4
ECN	111	Macroeconomic Principles	3
ENG	101	First-Year Composition	3
MAT	170	Precalculus Algebra	3
PHY	111	General Physics	3
PHY	113	General Physics Laboratory	1
Total			17

Second Semester

AET	182	Private Pilot Ground School	3
ECE	105	Introduction to Languages of Engineering	3
ENG	102	First-Year Composition	3
MAT	260	Technical Calculus I	3
PHY	112	General Physics	3
PHY	114	General Physics Laboratory	1
Total			16

STUDENT ORGANIZATIONS

The department hosts the local chapter of Alpha Eta Rho, the international professional aviation fraternity. Students also are eligible for membership in Tau Alpha Pi, the national honor society for engineering technology, American Association for Airport Executives (AAAE), and the Precision Flight Team, which competes in regional and national flying safety competitions. Department faculty also sponsor the ASU Radio Control Modelers, a student organization.

AERONAUTICAL TECHNOLOGY

Flight instruction costs are not included in university tuition.

AET 100 Primary Flight Course. (0) F, S, SS
Allows student to accrue flight time in preparation for the Private Pilot Certificate. Flight participation is required. Course may be repeated. Pre- or corequisite: AET 182 or equivalent.

182 Private Pilot Ground School. (3) F, S, SS
Ground school leading to FAA Private Pilot Certification. Student may begin flight training when concurrently enrolled in AET 100. Aerodynamics, navigation, performance, and regulations.

183 Private Pilot Certificate. (1) F, S, SS
Flight training for the FAA private pilot certificate. Satisfactory completion of FAA tests is required. Prerequisites: AET 182; passed FAA written.

200 Interim Flight Course. (0) F, S, SS
Allows students to accrue flight time in preparation for advanced ratings and certificates. Flight participation is required. Course may be repeated. Prerequisite: Private Pilot Certificate or instructor approval.

201 Air Traffic Control. (3) S
Ground and air operations. Weather services communications and routing. Flight plans and IFR operations. Departures and arrivals. Airport conditions and emergencies. Prerequisite: AET 182.

220 Aviation Meteorology. (3) F, S
Evaluation, analysis, and interpretation of atmospheric phenomena. Low and high altitude weather from the pilot's viewpoint. Nephology. Prerequisite: AET 182.

222 Instrument Pilot Ground School. (3) F
Ground school leading to the FAA Instrument Pilot Rating. 10 hours ground trainer included. Prerequisite: Private Pilot Certificate. Pre- or corequisite: AET 220.

280 Aerospace Structures, Materials, and Systems. (4) F
Basic aerodynamics, aerospace vehicle structures materials and systems. Inspection requirements and methods. Lecture, lab. Prerequisites: PHY 111, 113.

283 Instrument Pilot Rating. (1) F, S, SS
Flight training for the FAA Instrument Pilot Rating. Satisfactory completion of FAA Instrument Rating required. Not for Aeronautical Technology majors. Prerequisites: AET 222; passed FAA written.

287 Aircraft Powerplants. (4) F, S
Theory and performance analysis of gas turbine and reciprocating aircraft engines. Engine accessories, systems, and environmental control. Lecture, lab. Prerequisites: CHM 113 or 114; PHY 112, 114. Pre- or corequisite: MAT 260.

300 Aircraft Design I. (3) F, S
Basic applied aerodynamics, propeller performance, and airplane performance analysis. Prerequisites: AET 280, 287; ECE 106; MAT 260; PHY 112, 114.

308 Air Transportation. (3) F
Study of the historical and international development of air transportation and its social, political, and economic impact upon global interrelationships. Prerequisite: junior standing. *General studies: G.*

310 Instrumentation. (3) F
Measurement systems, components, system response, and the characteristics of experimental data. Methods of collecting and analyzing data. Lecture, lab. Prerequisites: ETC 201; MAT 261. Pre- or corequisite: MET 313.

312 Applied Engineering Mechanics: Dynamics. (3) F, S
Masses; motion kinematics; dynamics of machinery. Prerequisites: ETC 211; MAT 261.

314 Commercial Pilot Ground School. (3) S
Ground school leading to Commercial Pilot certification. 10 hours ground trainer included. Prerequisite: Private Pilot Certificate. Pre- or corequisite: AET 222.

320 Applied Aerodynamics and Wind Tunnel Testing. (4) S
Introduction to viscous and inviscid flow and their relationship to aircraft lift and drag. Wind tunnel design and testing. Lecture, lab. Prerequisites: AET 300; ECE 106; MAT 262.

342 Aviation Law/Regulations. (3) F
Study which encompasses the field of aviation within the context of the U.S. Common Law system. Public law, administrative rule making, sovereignty, enforcement, and case law analysis. Prerequisite: junior standing.

344 Airport Management and Planning. (3) S
Career orientation into administration and management of modern public airports, to include an overview of planning, funding, and development of airport facilities. Prerequisite: AET 308 or instructor approval.

360 Introduction to Helicopter Technology. (3) N
Introduction to the working functions of modern rotary wing aircraft. Rotary wing flight theory, aerodynamics, controls, flight, and power requirements. Prerequisites: PHY 111, 113; junior standing.

382 Air Navigation. (3) F
Advanced D.R., including theory/application of modern navigation systems, pressure pattern, and grid navigation. Prerequisite: AET 222.

383 Commercial Pilot Certificate and Instrument Rating. (2) F, S, SS
Flight training for the FAA Commercial Pilot Certificate with Airplane Single Engine Land and Instrument Airplane Ratings. Satisfactory completion of FAA Certificate/Rating required. Prerequisites: AET 222, 314; passed FAA written; flying time, 150 hours minimum.

385 Flight Instructor Ground School. (3) F
Ground school in preparation for the FAA Flight Instructor Certificate. Pre- or corequisite: AET 383.

386 Flight Instructor Certificate. (1) F, S, SS
Flight training for FAA Flight Instructor Certificate. Certificate required for course completion. Prerequisites: AET 385; passed FAA written.

387 Multi-Engine Ground School. (1) F
Ground school preparation for the FAA Multi-Engine Rating. Pre- or corequisite: AET 383 or instructor approval.

389 Multi-Engine Rating. (1) F, S, SS
Flight training for addition of an unrestricted FAA Multi-Engine Rating to a commercial pilot certificate. FAA rating required for course completion. Corequisite: AET 387.

391 Multi-Engine Instructor Ground School. (2) F, S
Ground school preparation for the FAA Multi-Engine Flight Instructor Rating. Prerequisites: AET 386, 387, 389.

392 Flight Instructor Instrument Ground School. (2) S
Ground School preparation for the FAA Instrument Flight Instructor Rating. Prerequisite: AET 386 or instructor approval.

393 Flight Instructor Instrument Rating. (1) F, S, SS
Flight training for the FAA CFII. CFII Rating required for course completion. Prerequisites: AET 386, 392; passed FAA written.

395 Multi-Engine Land, Airplane Flight Instructor Rating. (1) F, S, SS
Normal and emergency flight operations. Instruction techniques and procedures associated with light multi-engine land, airplane. CFIAME Rating required for course completion. Prerequisites: AET 386, 389.

408 National Airspace System. (2) F
Airway facilities. Operations and communications, air route traffic control centers, and flight service stations. Navigation aids, airport environment, certification, and security. Prerequisites: AET 201 (or 222), 344.

409 Nondestructive Testing and Quality Assurance. (3) F, S
Purpose of inspection and quality assurance. Theory and application of nondestructive inspection methods. Application of pertinent standards, specifications, and codes. Lecture, lab. Prerequisite: AET 280 or MET 230. Pre- or corequisite: ETC 400.

410 Aviation Safety. (3) F
Aviation accident prevention, human factors, life support, fire prevention, accident investigation, and crash survivability. Development and analysis of aviation safety programs. Prerequisite: junior standing; completion of 1 semester of literacy and critical inquiry (L1) requirement.

415 Gasdynamics and Propulsion. (3) F
Introduction to compressible flow, internal and external flow, and aerothermodynamic analysis of propulsion systems. Prerequisite: ETC 340; MAT 262.

417 Aerospace Structures. (3) F
Analysis and design of aircraft and aerospace structures. Shear flow. Semimonocoque structures. Effects of dynamic loading. Prerequisites: AET 300, 312, 320; MAT 262; MET 313.

487 Aircraft Design II. (3) S
Basic aerodynamics and airplane performance analysis methods applied to practical design project. Prerequisite: AET 300.

489 Airline Administration. (2) S
Administrative organizations, economics of airline administration, operational structure, and relationship with federal government agencies. Prerequisite: AET 308 or instructor approval.

490 Advanced Applied Aerodynamics. (3) S
Study of fluid motion and aerodynamics. Essentials of incompressible aerodynamics and computational fluid dynamics. Elements of laminar and turbulent flows. Lecture, lab. Prerequisites: AET 312; ECE 106; MAT 262.

Omnibus Courses: See page 44 for omnibus courses that may be offered.

Electronics and Computer Technology

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PROFESSORS
MAISEL, McHENRY, MUNUKUTLA

ASSOCIATE PROFESSORS
FORDEMWALT, McBRIEN, NOWLIN, WOOD

ASSISTANT PROFESSORS
MACIA, PETERSON, ZENG

VISITING ASSISTANT PROFESSOR
SADDLER

PROFESSORS EMERITI
BAXTER, EDWARDS, STRAWN

Purpose. Electronics engineering technology is a technological field of specialization that requires the application of scientific and engineering knowledge and methods combined with technical skills in support of electrical/electronics engineering activities. It lies in the occupational spectrum between the craftsman and the engineer at the end of the spectrum closest to the engineer. The electronics engineering technologist is a member of the electrical engineering team that consists of electrical engineers, electronics engineering technologists, and electronics engineering technicians.

The electronics engineering technologist is applications oriented, building upon a background of applied mathematics including the concepts and applications of calculus. Utilizing applied science and state-of-the-art technology, the electronics technologist is able to produce practical, workable, and safe results quickly and economically, to install and operate technical systems, to configure hardware for unique applications from proven concepts, to develop and produce products, to service machines and systems, to manage construction and production processes, and to provide customer support to technical products and systems.

Degrees. The Department of Electronics and Computer Technology offers the Bachelor of Science degree in Electronics Engineering Technology (B.S./EET). Four options are available: computer systems, electronic systems, microelectronics, and telecommunications.

The *computer systems* option combines applied electronics and computer hardware-software concepts and applications. It has been formulated to meet the needs of persons who wish to engage in digital and computer systems applications as a career focus.

The *electronic systems* option is aimed at preparing persons for careers in instrumentation, control, and power systems applications. This option allows a student to develop a broad-based knowledge of electrical/electronic fundamentals with an applications perspective. Sixteen of the 26 specialization hours are specified and the remaining 10 hours are approved technical electives. The Department of Electronics and Computer Technology has had a concentration in electronic systems or instrumentation and systems control for many years. The course patterns in support of these emphasis areas have been well developed and continue to provide strong support for the electronic systems option under the B.S./EET program.

The *microelectronics* (UET) option combines applied electronics, monolithic and hybrid integrated circuit processing and applications, device and component fabrication, and manufacturing. The objective of this option is to prepare persons to assume positions in the area of microelectronics manufacturing with immediately applicable knowledge as well as to develop a strong foundation of electronic fundamentals and methods. Students should be interested in the design, fabrication, and manufacture of imprinted circuitry, monolithic integrated circuits (bipolar and MOS), and hybrid thick film and thin film circuitry, components, and systems. Graduates of this program have various career opportunities in industry, particularly in semiconductor processing, fabrication, manufacturing, and device product application areas. The continuing explosion in semiconductor and related technologies and their applications to electronic and computer-related products offers unique and challenging opportunities. Graduates of this program option secure positions in processing, manufacturing, operations, and applications areas in industry as members of the diverse scientific engineering team.

The *telecommunications* option has been structured to take advantage of the recent changes in the telecommunications industry. The program encompasses the fundamentals of information and signal processing, modern bandwidth-efficient digital radio analysis with RF and microwave circuits and systems. Applications include telephone pulse code modulation, cable TV, fiber optic links, and satellite transmission circuits and systems.

A Master of Technology degree program with a concentration in electronics engineering technology is available for qualified B.S. graduates. The undergraduate program options are supported as emphasis areas in the master's degree program. See the *Graduate Catalog* for more information.

ELECTRONICS ENGINEERING TECHNOLOGY—B.S.

The departmental curriculum is organized into two categories, technical studies and general studies. Technical studies consist of core areas and the option specialty area. General studies consist of courses selected to meet the university general studies requirement as well as the math/science requirement of TAC/ABET. A minimum of 50 upper-division hours is required, including at least 24 semester hours of EET, CET, or UET upper-division hours to be taken at ASU. Complete program of study guides with typical four-year patterns are available from the department for each option.

The technical studies curriculum component consists of 91 semester hours of course work, which includes the engineering technology core (20 hours), electronics engineering technology core (45 hours), and an option (26 hours). The general studies portion of the B.S./EET curriculum has been carefully structured to meet the specific requirements of the university and to include the content required by TAC/ABET, the professional accrediting agency for such curricula.

DEGREE REQUIREMENTS

In addition to the courses listed for English proficiency, general studies, and the technology core, the following courses are required:

			Semester Hours
L1 elective:			
COM	225	Public Speaking	3
SB elective:			
ECN	112	Microeconomic Principles	3

Engineering Technology Core

The following courses are required as part of the engineering technology core:

			Semester Hours
CHM	113	General Chemistry	4
ETC	201	Applied Electrical Science	4
ETC	211	Applied Engineering Mechanics: Statics	3
ETC	340	Applied Thermodynamics and Heat Transfer	3
MAT	260	Technical Calculus I	3
MAT	261	Technical Calculus II	3
Total			20

Electronics Engineering Technology Core Requirements

			Semester Hours
CET	150	Digital Systems and Microprocessors	3
CET	350	Digital Logic Principles	4
CET	354	Microcomputer Principles	4
CET	483	Unix Utilities Using C Language	3
EET	205	Electronic Devices and Circuits	4
EET	208	Electric Circuits	3
EET	301	Electric Networks	3
EET	310	Electronic Circuits	4
EET	372	Communication Systems	4
EET	396	Professional Orientation*	1
MAT	262	Technical Calculus III	3
UET	331	Semiconductor Materials Science/Devices	3
UET	415	Electronic Manufacturing Engineering Principles	3
Total			42

* Students must take EET 396 the semester in which they are enrolled in the 87th hour of credit (ASU plus transfer hours). If this occurs in summer session, students should take EET 396 the prior spring semester.

Electronics Engineering Technology Options

Computer Systems. CET 452, 456, 457, 473; 11 hours of *approved* technical electives.

Electronic Systems. EET 307, 406, 430, 460; 10 hours of *approved* technical electives.

Microelectronics. CHM 116; UET 416, 417, 418, 432; 10 hours of *approved* technical electives.

Telecommunications Systems. CET 473; EET 304, 401, 470; 11 hours of *approved* technical electives.

Electronics Engineering Technology Program of Study

Typical First- and Second-Year Sequence

Freshman Year

First Semester

			Semester Hours
CET	150	Digital Systems and Microprocessors	3
ENG	101	First-Year Composition	3
MAT	170	Precalculus	3
PHY	111	General Physics	3
PHY	113	General Physics Lab	1
HU or SB elective			3
Total			16

Second Semester

ECE	105	Introduction to Languages of Engineering	3
ENG	102	First-Year Composition	3
ETC	201	Applied Electrical Science	4
MAT	260	Technical Calculus I	3
PHY	112	General Physics	3
PHY	114	General Physics Laboratory	1
Total			17

Sophomore Year

First Semester

CHM	113	General Chemistry	4
ECE	106	Introduction to Computer-Aided Engineering	3
EET	208	Electric Circuits	3
EET	205	Electronic Devices and Circuits	4
MAT	261	Technical Calculus II	3
Total			17

Second Semester

COM	225	Public Speaking	3
EET	372	Communication Systems	4
ETC	211	Applied Engineering Mechanics: Statics	3
HU or SB elective			3
MAT	262	Technical Calculus III	3
Total			16

STUDENT ORGANIZATIONS

The department hosts one of the local chapters of the Institute of Electrical and Electronics Engineers (IEEE), the International Society for Hybrid Microelectronics (ISHM), and the Instrument Society of America (ISA). Students may also be elected to membership in Tau Alpha Pi, the national honor society for engineering technology.

ELECTRONICS ENGINEERING TECHNOLOGY

EET 205 Electronic Devices and Circuits. (4) F, S
Active device characteristics, models, and basic circuit analysis. Lecture, lab. Prerequisite: ETC 201.

208 Electric Circuits. (3) F, S
Graphical and analytical analysis of electric circuits, transient, and sinusoidal excitation. Applications of circuit theorems and computer solutions. Pre- or corequisite: ETC 201; MAT 261.

301 Electric Networks. (3) F, S
Analysis of electric networks, transients, steady-state sinusoidal frequency response, and transfer function using Laplace transforms and Fourier Series. Prerequisite: EET 208. Pre- or corequisite: MAT 262.

304 Transmission Lines and Waveguides. (4) S
Theory and application of transmission lines, waveguides, antennas, microwave components, and impedance matching techniques. Lecture, lab. Prerequisite: EET 301.

307 Electrical Power Systems. (4) F
Electrical power systems analysis, generation, transmission, distribution and utilization, including system protection. Lecture, lab. Prerequisite: EET 208.

310 Electronic Circuits. (4) F, S
Multi-stage amplifier, analysis, and design using models and computer simulation. Lecture, lab. Prerequisites: EET 205, 208.

372 Communication Systems. (4) F, S
Systems analysis and design of AM, FM, PCM, and SSB communication systems. Noise and distortion performance of communication systems. Lecture, lab. Pre- and corequisites: EET 301, 310.

396 Professional Orientation. (1) F, S
Technical, professional, economic, and ethical aspects of electronics/computer engineering technology practice and industrial organization. Lecture, projects. Prerequisite: junior standing.

401 Digital Filters and Applications. (3) S
Analysis and design of digital filters. Time frequency and Z-transform techniques and waveform analysis. Computer applications. Prerequisites: EET 301; MAT 262.

406 Control System Technology. (4) S
Control system components, analysis of feedback control systems, stability, performance, and application. Lecture, lab, computer simulations. Prerequisites: EET 301; MAT 262.

410 Linear Filters and Applications. (3) A
Frequency response and feedback design of multistage electronic circuits. Active and passive filter design. Computer analysis. Prerequisites: EET 301, 310.

420 Operational Amplifier Theory and Application. (4) A
Differential and operational amplifiers, feedback configurations, op-amp errors and compensation, and linear and nonlinear applications. Lecture, lab. Prerequisites: EET 301, 310.

422 Electronic Switching Circuits. (4) A
Analysis and design of electronic circuits operating in a switching mode. Waveshaping, timing, and logic. Computer simulation. Lecture, lab. Prerequisites: CET 350; EET 301, 310.

430 Instrumentation Systems. (4) F
Measurement principles and instrumentation, techniques. Signal and error analysis. Lecture, lab. Prerequisites: EET 301, 310.

440 Electrical Power Systems Technology. (4) S
Principles and analysis of rotating machines, transformers, and related control equipment. Lecture, lab. Prerequisite: EET 307.

460 Power Electronics. (4) S
Analysis of circuits for control and conversion of electrical power and energy. Lecture, lab. Prerequisites: EET 301, 307, 310.

470 Communication Circuits. (4) S
Analysis and design of passive and active communication circuits. Coupling networks, filters, and impedance matching. Modulation and demodulation techniques. Computer solutions. Lecture, lab. Prerequisites: EET 372; MAT 262.

478 Digital Communication Systems. (3) S
Theory, design, and application of digital, data, and fiber optics communication systems. Prerequisites: EET 304, 372; MAT 262.

482 Industrial Practice: Internship/Coop. (1–4) F, S, SS
Specially assigned or approved activities in electronic industries or institutions. Report required. Maximum of 10 credits. Prerequisite: majors only enrolled at junior-senior level.

490 Electronics Project. (1–4) F, S, SS
Individual or small group projects in applied electronics, with emphasis on laboratory practice or hardware solutions to practical problems. Prerequisite: instructor approval.

501 Digital Signal Processing and Applications I. (3) F
Applications of discrete-time signals and systems, design of IIR and FIR filters using computer aided design techniques. Prerequisites: EET 401 or instructor approval; MAT 262.

502 Digital Signal Processing and Applications II. (3) S
Application of FFT, fundamentals of probability theory and random processes, and quantization effects in digital filters. Prerequisite: EET 501.

506 System Dynamics and Control. (3) S
Time, frequency, and transform domain analysis of physical systems. Transfer function analysis of feedback control systems performance and stability. Compensation. Prerequisites: EET 301, 501 (or MAT 262).

510 Linear Integrated Circuits and Applications. (3) F
Analysis, design, and applications of linear integrated circuits and systems. Prerequisites: CET 350; EET 301, 310.

522 Digital Integrated Circuits and Applications. (3) S
Analysis, design, and applications of integrated circuits and systems. Prerequisites: CET 350; EET 301, 310.

530 Electronic Test Systems and Applications. (3) F
Analysis, design, and application of electronic test equipment, test systems, specifications, and documentation. Prerequisites: CET 354; EET 301, 310.

540 Electrical Power Systems. (3) S
Electrical power system analysis, transmission, distribution, instrumentation, protection, and related system components. Prerequisites: EET 301, 307.

560 Industrial Electronics and Applications. (3) A
Analysis, design, and application of special electronic devices and systems to industrial control, power, communications, and processes. Prerequisites: CET 350; EET 301, 307, 310.

574 Microwave Amplifier-Circuits Design. (3) F
Analysis and design of microwave amplifier-circuits using s-parameter theory and computer aided design. Prerequisites: EET 304, 470.

576 Modern Telecommunication Systems. (3) F
Applied design and integration of microwave and satellite communication systems. Prerequisites: CET 473 and MAT 262 *or* instructor approval.

578 Digital Filter Hardware Design. (3) S
Hardware design of FIR and IIR filters, including adaptive filters, based on DSP chips. Develop new applications using DSP microprocessor systems. Prerequisites: EET 401; CET 354.

Omnibus Courses: See page 44 for omnibus courses that may be offered.

COMPUTER ENGINEERING TECHNOLOGY

CET 150 Digital Systems and Microprocessors. (3) F, S
Fundamentals of digital systems and microprocessors, with Boolean Algebra and combinational logic. Microprocessor programming and applications. Lecture, lab. Prerequisite: freshman standing. *General studies: N3.*

350 Digital Logic Principles. (4) F, S
Combinational and sequential logic analysis, design concepts, and applications. Lecture, lab. Prerequisite: CET 250.

354 Microprocessor Principles. (4) F, S
Microprocessor organization, programming, and interfacing. Pre- or corequisite: CET 250.

452 Digital Logic Applications. (4) S
Design of sequential machines using system design techniques and complex MSI/LSI devices with lab. Prerequisites: CET 350; CSE 183.

456 Assembly Language Applications. (3) F
Programming BIOS, DOS, and high level language interfaces. Device drivers and TRS routines. Prerequisites: CET 354; CSE 183 or 100.

457 Microcomputer Systems Interfacing. (4) S
Applications of microcomputer hardware and software. Special purpose controllers, interface design. Lecture, lab. Prerequisites: CET 354; CSE 183; EET 310.

458 Digital Computer Networks. (3) A
Network technology, topologies, protocols, control techniques, reliability and security. Prerequisite: CET 354.

473 Digital/Data Communications. (4) F, S
Signals, distortion, noise, and error detection/correction. Transmission and systems design. Interface techniques and standards. Lecture, lab. Prerequisites: CET 354; EET 372.

483 Unix Utilities Using C Language. (3) S
Applications of C language to the development of practical programs for the Unix operating system. Prerequisite: senior standing in technology or equivalent.

485 Digital Testing Techniques. (3) A
Hardware/software aspects of digital testing technology; systems, board, and logic testing and equipment. Lecture, lab. Prerequisites: CET 354; CSE 183; EET 310.

486 Electronics Computer Aided Design. (3) F
CAD/CAM for electronics manufacturing. Printed-circuit layout, documentation, and schematic plotting. Prerequisites: CET 250; CSE 183; EET 310.

508 Computer Process Control Technology. (3) A
Sample data control techniques and applications to process control. Prerequisites: CET 354; EET 406.

552 Digital Systems Design. (3) S
Digital system design techniques and applications. Prerequisite: CET 452 or instructor approval.

556 Computer Software Technology. (3) S
Assembly language programming techniques and operations, operating system characteristics, and systems software applications. Prerequisite: CET 354.

557 Microcomputers and Applications. (3) F
Applications of small computer systems, mini- and microcomputer hardware and software. Prerequisites: CET 354; CSE 100 or 183; EET 310.

Omnibus Courses: See page 44 for omnibus courses that may be offered.

MICROELECTRONICS ENGINEERING TECHNOLOGY

UET 331 Electronic Materials. (3) F, S
Physical, chemical, electromagnetic, and mechanical properties of electronic materials. Solid state device characteristics and their material properties. Prerequisites: CHM 113; EET 205; PHY 112, 114.

415 Electronic Manufacturing Engineering Principles. (3) F, S
Electronic equipment design and fabrication principles and practice. Completion of electronics hardware design project and report. Lecture, lab. With lab fee. Prerequisite: EET senior standing (113 hours).

416 Monolithic Integrated Circuit Devices. (3) F
Physics and electronics of bipolar and MOS devices used in integrated circuits. Prerequisite: UET 331. Corequisite: UET 417.

417 Monolithic Integrated Circuit Laboratory. (2) F
Laboratory practice in the fabrication of integrated circuits. Lab. Prerequisite: UET 331. Corequisite: UET 416.

418 Hybrid Integrated Circuit Technology. (4) S
Layout, fabrication, design, and manufacture of thin and thick film hybrid circuits. Lecture, lab. Prerequisites: EET 310; UET 331.

432 Semiconductor Packaging and Heat Transfer. (3) S
Packaging theory and techniques; hermetic and plastic assembly; thermal management; electrical characteristics and reliability. Prerequisites: ETC 340 and UET 331 *or* equivalents.

437 Integrated Circuit Testing. (3) S
Principles, techniques, and strategies employed at wafer level and final product testing, both destructive and nondestructive. Prerequisite: UET 416.

513 Microelectronics Technology. (3) A
Special processes, techniques, and advances in monolithic and hybrid technology. Emphasis on manufacturing practice and product application for LSI and VLSI. Seminar. Prerequisite: UET 416.

516 IC Processing Technology and Integration. (3) F
Monolithic IC process integration and fabrication technology. Lecture, lab. Prerequisite: UET 416.

518 Hybrid IC Technology and Applications. (3) S
Theory, processing, fabrication, and manufacturing of hybrid microelectronics devices and products. Applications. Prerequisite: UET 331 or equivalent or instructor approval.

Omnibus Courses: See page 44 for omnibus courses that may be offered.

Manufacturing and Industrial Technology

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ASSISTANT PROFESSORS
BARCHILON, HUMBLE

VISITING ASSISTANT PROFESSOR
BIEKERT

PROFESSORS EMERITI
AUTORE, BROWN, BURDETTE, BURK, CAVALLIERE, KEITH, KIGIN, KISIELEWSKI, LAWLER, MINTER, PARDINI, PRUST, ROE, ROOK, SHELLER, STADMILLER, WATKINS, WILCOX

Purpose. Technology is the application of science, systematic methods, techniques, procedures, machines, materials, and devices for the development, improvement, and implementation of state-of-the-art solutions to industrial problems. Increased complexity and sophistication have created great demand for those individuals who possess a working knowledge of the technical phases of planning, testing, production, and fabrication of consumer and industrial products and equipment. Emphasis is placed on health and safety within the workplace.

The mission of the department is to prepare graduates who are able to develop and communicate technological solutions to industrial problems, to perform management functions in systems operations, to improve and evaluate products, to provide customer support, and to facilitate technology transfer in industry and government.

Majors and Emphases. To accomplish the mission, the department offers two majors leading to the Bachelor of Science degree, Industrial Technology and Manufacturing Engineering Technology. Three emphasis areas are available under the Industrial Technology major, which is accredited by the North Central Association of Colleges and Secondary Schools (NCACSS): graphic communications, industrial management, and interactive computer graphics. Five emphasis areas are available under the Manufacturing Engineering Technology (MET) major, which is accredited by the Technology Accreditation Commission of the Accreditation Board for Engineering and Technology: computer-integrated manufacturing engineering technology, manufacturing engineering technology, mechanical engineering technology, robotic and automation engineering technology, and welding engineering technology.

The department fosters research in disciplines of technology to support its educational programs, offers courses in support of the general education requirements of the university, and offers Master of Technology degree programs.

Admission. Those students who seek admission to the program from other programs within the College of Engineering and Applied Sciences may be admitted with a minimum GPA of 2.25 for Arizona residents and 2.50 for nonresidents. Students admitted to the program are required to develop an area of emphasis.

DEGREE REQUIREMENTS

Manufacturing Engineering Technology—B.S.

	Semester Hours
Engineering technology core	16
General studies requirements	45
Manufacturing Engineering Technology major	50
Selected emphasis area	15
University English proficiency	6
Total	132

The following courses constitute the Manufacturing Engineering Technology major and are required of all Manufacturing Engineering Technology students. Refer to the specific emphasis areas below for additional requirements.

Manufacturing Engineering Technology Major

			Semester Hours
MET	231	Manufacturing Processes	3
MET	300	Applied Material Science	4
MET	302	Welding Survey	3
MET	303	Machine Control Systems	3
MET	313	Applied Engineering Mechanics: Materials	4
MET	331	Design for Manufacturing I	3
MET	341	Manufacturing Analysis	3
MET	344	Casting and Forming Processes	3
MET	345	Advanced Manufacturing Processes	3
MET	346	Numerical Control Point to Point and Continuous Path Programming	3
MET	401	Statistical Process Control	3
MET	416	Applied Computer Integrated Manufacturing	3
MET	444	Production Tooling	3
MET	451	Introduction to Robotics	3
MET	460	Manufacturing Capstone Project I	3
MET	461	Mechanical Capstone Project II	3
Total			50

Computer-Integrated Manufacturing Engineering Technology. Computer-integrated manufacturing (CIM) has proved to be a powerful tool for increasing productivity in manufacturing. This impact will be greater in the future as the full potential of computers is integrated into the manufacturing factory. Computer-integrated manufacturing engineering technology is concerned with the coordination of computer information and computer implementation in manufacturing.

Required courses: MET 448, 452, 494; six hours approved technical electives.

Manufacturing Engineering Technology. This emphasis area is designed to prepare technologists with both conceptual and practical applications of processes, materials, and products related to metalworking industries. Accordingly, this concentration is intended to prepare students to meet the responsibilities in planning the processes of production, developing the tools and machines, and integrating the facilities of production or manufacturing.

Required courses: AET 409; MET 442; nine hours approved technical electives.

Mechanical Engineering Technology. The primary objective of the mechanical engineering technology emphasis area is to prepare the student for entry-level work in mechanical design and testing either in engineering or manufacturing departments in product-oriented industries. Major emphasis is placed on reducing the amount of time required by industry to make the graduate productive in any area of work. The student obtains a well-rounded academic background with an emphasis in mechanics and thermal sciences.

Required courses: MET 434, 436, 438; six hours of approved technical electives.

Robotic and Automation Engineering Technology. The challenges to improve productivity, product quality, and reliability and to reduce costs must be addressed by integrating robots and automation in manufacturing. This emphasis area addresses the field of automating manufacturing processes.

Required courses: MET 448, 452, 453; six hours approved technical electives.

Welding Engineering Technology. This emphasis area is designed primarily to prepare individuals for technical positions in industries utilizing welding and related processes. The focus is on the application of welding technology as applied to current and near future industrial needs. The program is structured to provide the individual with a balance of theory, application, and hands-on experience. The general areas covered by the courses are welding processes, materials, nondestructive testing, and weldment design. The student also has the opportunity to work with robots in robotic welding applications. Also, a laser is available for investigating the area of high-energy welding processes.

Graduates of this program have the capability to function in a variety of technical positions related to welding and manufacturing. Typically, a graduate from this program may work in the areas of robotic welding, metallurgy, quality control, nondestructive evaluation, welding process evaluation, and technical sales.

Graduates may find employment in the aerospace, automotive, heavy machinery, heavy fabrication, and energy production industries.

Required courses: MET 321, 420, 421, 425; three hours of approved technical electives.

Industrial Technology—B.S.

	Semester Hours
Industrial Technology core	25
General studies requirements	39
Industrial Technology major	62
First-year composition requirement	6
Total	132

The following courses constitute the Industrial Technology Core and are required of all Industrial Technology students. Refer to the specific emphasis areas for additional requirements.

Industrial Technology Core

			Semester Hours
ECE	105	Introduction to Languages of Engineering	3
ECE	106	Introduction to Computer-Aided Engineering	3
ETC	201	Applied Electrical Science	4
ITC	200	Impact of Communications Technology on Society	3
ITC	202	Creative Thinking and Design	3
ITC	343	Occupational Safety	3
ITC	346	Management Dynamics	3
MET	230	Engineering Materials	3
Total			25

Graphic Communications (GRC). The purpose of the graphic communications emphasis is to prepare people for a wide variety of professional positions in the printing and graphic communications industry. This area of emphasis offers a blend of technological and managerial skills and knowledge. It has been specifically designed to prepare graduates to address the opportunities and increased competitive challenges taking place in the industry as a result of technological change and turbulent economic and human relations concerns.

All courses are industry responsive. The students are exposed to case histories and problems related to actual industry issues. Throughout the entire four-year curriculum, students are exposed to practical, situational analysis and effective problem-solving techniques. As a prerequisite for graduation, students are expected to acquire job-related industry experience as practical preparation for making an immediate contribution to an employer's business.

To achieve its objectives, the graphic communications emphasis area requires 35 semester hours of technical GRC elective courses to be determined by advisement.

Typical career paths may include operations management, sales and marketing, and technology described below:

Operations Management. Computer graphics applications; conformance requirements for government regulation; decision making in a manufacturing environment; industrial cost accounting; instrumentation for graphic arts manufacturing; manufacturing strategy; materials testing and performance prediction; optimization of production systems; organizations and layout; planning and scheduling for manufacturing; plant design, plant information systems; printing systems maintenance; product development and management; production management; production coordination; supervisory techniques; traffic management.

Sales/Marketing. Customer education; estimating and job costing; finance, personnel and human relations; markets for printing; print and electronic media; sales management; sales service; strategic planning; market planning.

Technology. Analytical modeling for manufacturing systems; applied electronics for the graphic communications industry; creation, management and transmission of digital imaging information; environmental control; evaluation of new technologies; integrated computer graphics; printing plant engineering; quality management and process control; scientific properties of graphic communications materials; technological planning and forecasting.

Industrial Management. The purpose of this emphasis is to prepare supervisors and high-level personnel for management functions in industry, manufacturing, and public service organizations.

The industrial management emphasis is articulated with the Maricopa Community College District, Pima Community College, and Yavapai College. Consultation with an advisor is required to coordinate the course selection for transfer to the industrial management areas of emphasis. Classes are scheduled to accommodate the student who is employed in a full-time position.

To achieve its objectives, the industrial management emphasis area requires 35 semester hours of technical IST elective courses to be determined by advisement.

Technical electives to support the area of emphasis must be chosen by the student in consultation with an advisor. Typical areas for technical electives are aeronautics, construction, electronics, fire science, graphic communications, hazardous materials and waste management, interactive computer graphics, safety and health, technology, and manufacturing. Articulation agreements are to be followed by consulting an advisor.

Interactive Computer Graphics. The purpose of the interactive computer graphics (ICG) emphasis is to prepare students for entry into the diverse field of computer graphics. The ICG emphasis provides a strong academic foundation in the technological, managerial, and discipline-specific applications of graphics analysis, communication, databases, design, documentation, image generation, modeling, programming, and visualization.

Graduates are qualified computer graphics technologists who have acquired extensive knowledge and technical competency, thereby preparing them to advance into professional positions of leadership within the industry. The ICG courses are industry responsive and provide a high level of technical applicability in the use of computer graphics systems, hardware, and software within a variety of discipline environments.

Typical career paths may include: applications development, applications management and supervision; business and analytical graphics; design (specialty areas such as electronics, advertising/graphics design, mechanical, manufacturing, multimedia, animation, rendering and illustration, and computer-aided design and drafting); field engineering, service and support; graphics systems and database analysis; sales and marketing; technical graphics and publication; testing, and implementation; training (administration and instruction).

To achieve its objectives, the interactive computer graphics emphasis area requires 35 semester hours of technical ICG elective courses to be determined by advisement.

Technical electives to support the emphasis area must be chosen by the student in consultation with an advisor.

INDUSTRIAL TECHNOLOGY

ITC 200 Impact of Communications Technology on Society. (3) F, S
Developing an awareness of issues such as privacy, depersonalization, and control of information that have been affected by recent developments in communications technology. Activities include researching, evaluating findings, and presenting arguments in support of positions. Prerequisite: ENG 102 or 105 or 108. *General studies: L1.*

202 Creative Thinking and Design. (3) F, S
Fundamental methods, concepts, and techniques of creative thinking, design, and problem solving. Also includes communication, managerial, cultural, and societal influences. Lecture, lab. Prerequisite: ECE 106 or instructor approval.

343 Occupational Safety. (3) F
Accident prevention, accident factors, methods of recording and reporting, analysis, psychological aspects, attitudes, recent legislation, safety consciousness, and liability. Prerequisite: junior status.

444 Industrial Organization. (3) S
Industrial organization concepts. Topics relate to industrial relations, governmental regulations, organizational structure, labor relations, human factors, and current industrial practices. Field trips. Prerequisite: junior status.

Omnibus Courses: See page 44 for omnibus courses that may be offered.

GRAPHIC COMMUNICATIONS

GRC 135 Graphic Communications. (3) F, S
Introduction to the technologies involved in the design image generation, transmission, and production of multiple images for consumer utilization. Lecture, lab, field trips.

136 History of Printing in the Western World. (3) N
Historical perspective of technological developments in printing and social impacts on Western civilization in relation to other forms of communication. Field trips.

237 Introduction to Composition Systems. (3) F
An introduction to traditional and electronic composition systems and procedures used in the graphics communication industry including desktop publishing. Lecture, lab.

331 Quality Assurance for the Reproduction Processes. (3) S
Instrumentation and methodologies for materials testing and quality control in the major reproduction processes. Field trips.

332 Film Assembly and Platemaking. (3) F
Stripping negatives and positives; line, halftone, duo-tone, and full color; contacting flats onto various types of image carriers. Lecture, lab, field trips. Prerequisite: GRC 135.

333 Sheetweb Press Technology. (3) S
Function of the offset printing equipment. Lithographic dynamics of both sheetfed and sheetweb systems. Lecture, lab. Prerequisite: GRC 332 or instructor approval.

334 Image Conversion. (3) F
Theory and production of line work, halftones, contact work, and special effects for the graphic arts industry. Lecture, lab.

335 Printing and Finishing Techniques. (3) S
Analysis of major printing processes of flexography, screen process, and relief; production bindery and finishing procedures. Prerequisite: GRC 135.

336 Color Separation. (3) S
Methods of producing separation negatives and positives. Prerequisite: GRC 334.

337 Production Management. (3) F
Planning and controlling work flow of graphic arts products. Field trips. Prerequisite: GRC 135.

339 Estimating and Cost Analysis. (3) S
Management relationship between financial, production, and sales departments in printing industries; analysis of equipment, labor, and material costs; use of paper and standard pricing catalogs. Prerequisite: GRC 135.

433 Production Techniques. (3) N
Systematic production planning experience. Lecture, lab. Prerequisites: GRC 333, 334.

435 Plant Management. (3) F
Concepts, practices, and processes used by the commercial printing plant manager relating to the operation of the plant. Prerequisite: GRC 135 or instructor approval.

436 Gravure Technology. (3) S
In-depth study of the market profile and production sequences related to the gravure method of printing. Prerequisite: GRC 336.

437 Advanced Color Reproduction. (3) F
Scientific analysis for the engineering of color reproduction systems used in the graphic arts industry. Field trips. Prerequisite: GRC 336.

438 Graphic Arts Techniques and Processes. (3) F, S, SS
Survey of production sequences and profile of the printing and publishing industry. Lecture, lab. Prerequisite: junior standing.

439 Electronic Publishing Systems. (3) S
The study of electronic publishing systems and how text and graphics are integrated into a publication using desktop publishing technologies.

537 Current Issues in Quality Assurance. (3) N
Directed group study of selected issues relating to quality assurance in the printing and publishing industry.

Omnibus Courses: See page 44 for omnibus courses that may be offered.

INDUSTRIAL MANAGEMENT

IST 346 Management Dynamics. (3) S
Elements of human relations training and the consequences of supervisory behavioral patterns in effectively dealing with employees.

402 Industrial Laws, Contracts, and Regulations. (3) F
Review of city, state, county, and federal laws that affect industrial and construction operations, materials, supplies, and acquisition procedures.

430 Ethical Issues in Technology. (3) N
Topics in social responsibility for industrial technology and engineering.

445 Industrial Internship. (1–10) F, S, SS
Work experience assignment in industry commensurate with student's program. Specialized instruction by industry with university supervision. Prerequisites: advisor approval; junior status; 2.50 GPA.

451 Materials Control. (3) F
Activities of material handling, including purchasing, receiving, warehousing, traffic, plant layout, inventory, and production control and shipping relating to technical procedures.

452 Industrial Human Resource Management. (3) F, S
Concepts and practices of human resource management in a global industrial environment.

453 Safety Management. (3) S
Development and management of safety programs, education and training, and relationships within an organization. Prerequisite: ITC 343 or instructor approval.

454 Occupational Hygiene. (3) S
Offers an overview of occupational health hazards, their recognition, evaluation, and control. Discusses how industries are regulated and how occupational health standards are promulgated. Prerequisites: CHM 101 or 113 or 114; MAT 118.

455 Industrial Sales and Demand. (3) F
Customer and sales strategies for industrial organizations, including current practice and future planning. Prerequisites: ECN 111; advisor and instructor approval; junior standing.

460 Risk and Legal Aspects of Safety. (3) F
Examines the risk management factors of industrial activities, including legal and insurance considerations.

461 Production Supervision Principles. (3) F
Introduction to supervisory principles as applied to production of goods and services. Prerequisite: ITC 444.

480 Organizational Effectiveness. (3) F, S
Human aspects of supervisory behavior in the industrial setting and how they influence efficiency, morale, and organizational practice. Prerequisite: IST 346.

491 Introduction to Labor Concerns. (3) S
Introduction to labor relations, organization of labor unions and federations, collective bargaining, grievances and arbitration, and applicable labor legislation.

501 Principles of Hazardous Materials and Waste Management. (3) S
Establishes a foundation for the remaining courses in the curriculum. Topics include definitions of toxic and hazardous substances and wastes, RCRA classification, and OSHA criteria. Pre- or corequisites: CHM 101 or 113 or 114; MAT 118.

502 Regulatory Framework for Toxic and Hazardous Substances. (3) S
Provides an in-depth examination of federal, state, and local regulations and requirements for hazardous materials and wastes. Includes an overview of legislative history and trends, industry's role in regulatory development, and its impact. Prerequisite: IST 501.

503 Principles of Toxicology. (3) S
Provides detailed information about the interaction of chemicals with living systems and the environment. Topics include mechanisms of toxic action, dose-response relationships, toxicity testing models, predictive toxicology and epidemiology. Prerequisite: CHM 101 or 113 or 114.

504 Technology for Storage, Treatment, and Disposal of Hazardous Materials. (3) F
A highly technical course which discusses current technologies, state-of-the-art technologies, and future trends for storage, treatment, and disposal of hazardous materials and waste. Prerequisites: CHM 101 or 113 or 114; IST 501.

505 Quantitative Analysis and Practical Laboratory Techniques. (3) F, S
Examines lab techniques for evaluation of hazardous materials, and discusses how to interpret data from analytical processes and regulatory lab requirements like SW 846. Lab will be arranged off site. Prerequisites: CHM 101 or 113 or 114; MAT 118.

506 Chemistry of Hazardous Materials. (3) F
Provides the chemical information needed for handling spilled hazardous substances. Includes response needs for oxidizers, organics and inorganics, and basic toxicology needs. Prerequisites: CHM 101 or 113 or 114; IST 501; MAT 118.

522 Air Pollution and Toxic Chemicals. (3) F
Examines issues in the measurement analysis and control of toxic chemicals in air pollution. Prerequisites: CHM 101 or 113 or 114; IST 501; MAT 118.

523 Soils and Groundwater Contamination. (3) A
Presents a detailed discussion and examination of theoretical and practical hydrogeology as it applies to cleaning up contamination. Investigative techniques, monitoring, risk assumptions, and assessment methodology will be addressed. Prerequisites: CHM 101 or 113 or 114; IST 501, 505; MAT 118.

524 Emergency Preparedness, Response, and Planning for Hazardous Materials. (3) S
Techniques for in-house or on-site emergency response contingency planning. Plan and develop an emergency response plan, including preemergency assessment, resources for cooperation, equipment requirements, and coordination with other agencies or resources. Prerequisites: CHM 101 or 113 or 114; IST 501; MAT 118.

525 Risk Assessment for Hazardous Materials. (3) F
Examines the risk assessment process and its application in various situations ranging from citing hazardous facilities regulation to control of toxic substances in the environment. Prerequisites: CHM 101 or 113 or 114; IST 501; MAT 118.

526 Current Issues: Radon, Asbestos. (3) S
Deals with the latest up-to-date topics in toxics management. New subjects may be added and others deleted as issues of the day become apparent. Prerequisites: CHM 101 or 113 or 114; IST 501; MAT 118.

527 Environmental/Resources Regulations Concepts. (3) A
Covers development of environmental, natural resources and water law, from common law to modern statutory requirements. Specifics on Superfund, hazardous materials and toxics regulations and liability contracts. Prerequisites: CHM 101 or 113 or 114; IST 501.

542 Global Management Philosophies. (3) F
Analysis and comparison of significant supervision philosophies developed in various industrial nations and their potential application in the United States.

549 Research Techniques and Applications. (3) F, S
Selection of research problems, analysis of literature, individual investigations, preparing reports, and proposal writing.

550 Industrial Training. (3) S
Training techniques and learning processes. Planning, developing, and evaluating training programs in industry and governmental agencies. Prerequisite: advisor approval.

570 Project Management. (3) S
Planning, organizing, coordinating, and controlling staff and project groups to accomplish the project objective.

598 Special Topics. (1–3) F, S, SS
Special topics courses, including the following, which are regularly offered, are open to qualified students. These courses are taught Fridays, Saturdays, Sundays, and Mondays at ASU Research Park:

(a) Principles of Hazardous Materials and Waste Management
(b) Regulatory Framework for Toxic and Hazardous Substances
(c) Principles of Toxicology
(d) Technologies for Storage, Treatment, and Disposal of Hazardous Materials
(e) Quantitative Analysis and Practical Laboratory Techniques
(f) Occupational Hygiene
(g) Air Pollution and Toxic Chemicals
(h) Soils and Groundwater Contamination
(i) Emergency Preparedness, Response, and Planning for Hazardous Materials
(j) Risk Assessment for Hazardous Materials
(k) Current Issues: Radon, Asbestos, and USTs

Omnibus Courses: See page 44 for omnibus courses that may be offered.

INTERACTIVE COMPUTER GRAPHICS

ICG 212 Design Documentation. (3) S
Using microcomputer-based graphics systems for product design and documentation. Geometric shape analysis and description. Documentation techniques and standards. Dimensioning. Lecture, lab, field trips. Prerequisite: ECE 106.

310 Computer Graphics Fundamentals. (3) S
Computer image creation, transformation, and manipulation. Current techniques for database generation. Concepts of applications software development. Hands-on experience. Lecture, lab, field trips. Prerequisite: programming background helpful but not necessary. *General studies: N3.*

312 Computer-Aided Design and Drafting. (3) F
Using computer-aided design and drafting application software for advanced geometric construction. System and workstation configuration and productivity. Modeling applications. Lecture, lab, field trips. Prerequisite: ICG 212. *General studies: N3.*

313 Technical Illustration. (3) F
Pictorial drawing, shades and shadows, and multimedia rendering techniques. Lecture, lab. Prerequisite: ICG 212.

314 Computer Graphics Database. (3) S
Preparing the product definition database for computer-integrated manufacturing. Documentation and process requirements, systems, and standards. Precision dimensioning. Lecture, lab, field trips. Prerequisite: ICG 212 or instructor approval.

412 Computer Graphics Modeling. (3) F
Establishing and manipulating 3-dimensional computer models. Applications, including solids modeling concepts, design analysis, dynamic simulation, and graphic data exchange files. Lecture, lab, field trips. Prerequisite: ICG 312. *General studies: N3.*

413 MicroCADD Applications. (3) F
Student selected modules, including architectural, construction, civil utility, and electronic drawing; mechanical manufacturing, animation, computer graphics, and others. Lecture, lab, field trips. Prerequisite: ICG 212.

417 Graphics Systems Management. (3) S
Planning, implementing, and managing computer graphics systems. Applications, needs assessment, analysis of components, system ergonomics, interfacing, maintenance, and human resources management. Lecture, lab, field trips. Prerequisite: instructor approval.

461 Computer Animation. (3) F
Fundamental technology used in creating 2-dimensional and 3-dimensional animation through modeling, scripting, and rendering as related to engineering simulation. Lecture, lab, field trips. Prerequisite: ICG 310 or instructor approval.

517 Graphics Systems Development. (3) S
Research and development in computer graphics systems. Applied project management, development, evaluation, and implementation. Lecture, lab, field trips. Prerequisite: ICG 412 or instructor approval.

Omnibus Courses: See page 44 for omnibus courses that may be offered.

MANUFACTURING TECHNOLOGY

MET 110 Welding Survey. (3) N
Oxyacetylene, arc, brazing, resistance, and gas tungsten-arc welding procedures for ferrous and nonferrous metals. Lecture, lab.

116 Aeronautical Welding. (2) F
Oxyacetylene and tungsten gas tungsten-arc welding procedures and brazing techniques used for aircraft structures. Lecture, lab.

230 Engineering Materials and Processing. (3) F, S, SS
Materials, their structures, properties, fabrication characteristics, and applications. Material forming, joining, and finishing processes. Automation and quality control. Prerequisite: CHM 101 or 113 or 114.

231 Manufacturing Processes. (3) F
Metal removal processes, emphasizing drilling, milling, and lathe processes, including tool bit grinding. Emphasis on production speeds and feeds. Lecture, lab. Prerequisites: ECE 106; MET 230.

300 Applied Material Science. (4) F
Principles of materials science emphasizing concepts relevant to manufacturing and use. Discuss metals, polymers, ceramics, and composites. 3 hours lecture, 1 hour lab. Prerequisite: MET 230 or instructor approval.

302 Welding Survey. (3) F
Theory and application of industrial welding processes; introductory welding metallurgy and weldment design; SMAW, GTAW, GMAW, Oxyacetylene, and brazing experiences. Lecture, lab. Prerequisite: upper-class standing.

303 Machine Control Systems. (3) S
Theory and application of electromechanical, hydraulic, pneumatic, fluidic, and electrical control systems for manufacturing. Lecture, lab. Prerequisites: ETC 201 or PHY 112; MAT 260.

313 Applied Engineering Mechanics: Materials. (4) F, S, SS
Stress, strain, relations between stress and strain, shear, moments, deflections, and combined stresses. 3 hours lecture, 1 hour lab. Prerequisite: ETC 211.

321 Engineering Evaluation of Welding Processes. (3) N
Theory and application of the arc welding processes and oxy-fuel cutting; fixturing, procedures, safety, codes, and experimental techniques are covered. Lecture, lab. Prerequisites: MET 302; PHY 112.

322 Engineering Evaluation of Nontraditional Welding Processes. (3) N
Theory and applications of EBW, LBW, solid state bonding, brazing, and soldering. Lecture, lab. Prerequisites: MET 302; PHY 112.

325 Electrical Power Source Analysis. (4) S
Design and operating characteristics of electrical power sources and related equipment. Equipment selection, setup, and troubleshooting procedures covered. Lecture, lab. Prerequisites: ETC 201; MET 302; PHY 112, 114.

331 Design for Manufacturing I. (3) S
Introduction to design of machines and structures, with emphasis on layout design drawing. Basics of gears, cams, fasteners, springs, bearing linkages, cylindrical fits, flat pattern development, and surface finish requirements emphasized. Prerequisite: MET 313.

341 Manufacturing Analysis. (3) S
Introduction to the organizational and functional requirements for effective production. Includes writing production operation plans. Prerequisite: MET 231.

343 Material Processes. (4) S
Industrial processing as applied to low, medium, and high volume manufacturing. Basic and secondary processing, fastening and joining, coating, and quality control. Lecture, lab.

344 Casting and Forming Processes. (3) S
Analysis of various forming processes to determine load requirements necessary for a particular metal forming operation. This information is used to select equipment and design tooling. Metal casting processes and design of castings. Introduction to powder metallurgy. Prerequisites: MET 300 and 313 *or* instructor approval.

345 Advanced Manufacturing Processes. (3) S
Metal removal processes, emphasizing milling, grinding, turret and tracer lathe, and cutter sharpening. Application of machinability theory to practice. Production feeds, speeds, and tool wear measurement. Lecture, lab. Prerequisites: MET 231 and 300 *or* instructor approval.

346 Numerical Control Point to Point and Continuous Path Programming. (3) N
Methods of programming, set up, and operation of numerical control machines, emphasizing lathe and mill systems. Lecture, lab. Prerequisite: MET 231.

354 Mechanics of Materials. (4) F
Vectors, force systems, friction, equilibrium, centroids, and moment of inertia. Concepts of stress, strain, and stress analysis as applied to beams, columns, and combined loading. Nonmajors only. Prerequisites: MAT 118; PHY 111.

401 Statistical Process Control. (3) S
Introduction to statistical quality control methods as applied to tolerances, process control, sampling, and reliability. Prerequisite: MAT 118.

407 Aerospace Materials. (2) N
Materials used for aircraft powerplants and airframes; emphasis on criteria for selection in terms of mechanical properties and manufacturing processes. Prerequisite: MET 230 or equivalent.

416 Applied Computer Integrated Manufacturing. (3) F
Techniques and practices of Computer Integrated Manufacturing, with an emphasis on Computer-Aided Design and Computer-Aided Manufacturing. Prerequisite: MET 346 or instructor approval. *General studies: N3.*

420 Welding Metallurgy I. (4) N
Metallurgical principles applied to structural and alloy steel and aluminum weldments; laboratory emphasis on welding experiments, metallography, and mechanical testing. Lecture, lab. Prerequisites: MET 300, 302.

421 Welding Metallurgy II. (3) N
Metallurgical principles as applied to stainless steel, super alloy, titanium, and other refractory metal weldments and braze joints. Prerequisite: MET 300.

425 Welding Codes. (2) N
Familiarization with and application of the various codes, standards, and specifications applicable to weldments. Prerequisite: MET 302 or equivalent.

432 Applied Thermodynamics and Heat Transfer. (3) F, S
Thermodynamics of mixtures. Combustion process. Applications of thermodynamics to power and refrigeration cycles. Heat transfer, including steady state conduction, convection, and radiation. Prerequisite: ETC 340.

433 Thermal Power Systems. (4) N
Analysis of gas power, vapor power, and refrigeration cycles. Components of air conditioning systems. Direct energy conversion. Psychrometry. Analysis of internal combustion engines and fluid machines. Lecture, lab. Prerequisite: MET 432 or instructor approval.

434 Applied Fluid Mechanics. (4) N
Fluid statics. Basic fluid flow equations. Viscous flow in pipes and channels. Compressible flow. Applications to fluid measurement and flow in conduits. Prerequisite: ETC 340.

436 Turbomachinery Design. (3) N
The application of thermodynamics and fluid mechanics to the analysis of machinery design and power cycle performance predictions. Prerequisite: MET 432 or instructor approval.

438 Design for Manufacturing II. (4) F
The application of mechanics in the design of machine elements and structures. The use of experimental stress analysis in design evaluation. Lecture, lab. Prerequisites: AET 312 and MET 231 and 331 *or* instructor approval.

442 Specialized Production Processes. (3) F
Nontraditional manufacturing processes, emphasizing EDM, ECM, ECG, CM, PM, HERF, EBW, and LBW. Prerequisite: MET 230.

443 N/C Computer Programming. (3) F
Theory and application of computer-aided N/C languages with programming emphasis with APT and suitable postprocessors. Lecture, lab. Prerequisite: MET 346 or instructor approval.

444 Production Tooling. (3) F
Fabrication and design of jigs, fixtures, and special industrial tooling related to manufacturing methods. Lecture, lab. Prerequisite: MET 345.

448 Expert Systems in Manufacturing. (3) F
Introduction to expert systems through conceptual analysis, with an emphasis on manufacturing applications. Prerequisite: MET 231.

451 Introduction to Robotics. (3) F
Introduction to industrial robots. Topics included are robot geometry, robot workspace, trajectory generation, robot actuators and sensors, design of end effectors, and economic justification. Prerequisite: MET 303 or instructor approval.

452 Implementation of Robots in Manufacturing. (3) N
Robotic workcell design, including end effectors, parts presentors, and optimum material flow. Prerequisite: MET 451 or instructor approval.

453 Robotic Applications. (3) S
Lab course utilizing robots and other automated manufacturing equipment to produce a part. Students are required to program robots, as well as interface the robots with other equipment. Prerequisite: MET 303 or 325 or instructor approval.

460 Manufacturing Capstone Project I. (3) F
Small-group projects to design, evaluate and analyze components, assemblies, and systems. Lecture, lab. Prerequisite: MET 303 or instructor approval.

461 Manufacturing Capstone Project II. (3) S
Small-group projects applying manufacturing techniques, with an emphasis on demonstrating state-of-the-art technology. Lecture, lab. Prerequisite: MET 460 or instructor approval.

462 Capstone Project/Weldment Design. (3) S
Design of welded structures and machine elements in terms of allowable stresses, joint configurations, process capabilities, and cost analysis; welding procedures emphasized. Prerequisites: MET 302, 313.

517 Applied Computer Integrated Manufacturing. (3) F
Techniques and practices of Computer Integrated Manufacturing, with an emphasis on Computer-Aided Design and Computer-Aided Manufacturing. Prerequisite: MET 346 or instructor approval.

542 N/C Computer Programming. (3) F
Theory and application of computer-aided N/C languages with programming emphasis with APT and suitable postprocessors. Application case studies are included. Lecture, lab. Prerequisite: MET 346 or instructor approval.

552 Introduction to Robotics. (3) F
Introduction to industrial robots. Topics included are robot workspace, trajectory generation, robot actuators and sensors, design of end effectors, and economic justification. Application case studies. Prerequisite: MET 303 or instructor approval.

Omnibus Courses: See page 44 for omnibus courses that may be offered.