Drexel University

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Table of Contents

The College of Engineering Graduate Programs

The College of Engineering

As Drexel moves into the 21st century, the College of Engineering remains the flagship college of the university, offering students a truly diverse academic learning and research environment, while continuing to build on its national reputation for excellence in engineering and research.

The College of Engineering offers graduate degree programs in the following disciplines:

- Biochemical Engineering
- Chemical Engineering
- Civil Engineering
- Computer Sciences
- Electrical Engineering
- Computer Engineering
- Telecommunications Engineering
- Engineering Management
- Environmental Engineering
- Master of Engineering
- Materials Engineering
- Mechanical Engineering and Mechanics

In addition, the College offers a multidisciplinary program in Software Engineering and Engineering Management in concert with other Drexel University colleges.

Biochemical Engineering

Graduate study in biochemical engineering is offered on a regular full-time basis. The core courses are designed for students with an undergraduate training in chemical engineering. However, students with a background in biological sciences can also enroll in those courses after completing the necessary basic engineering courses as prerequisites. Programs for such individuals will be determined after consultation with the departmental graduate adviser.

For more information, visit the Chemical and Biological Engineering Department web page.

Master of Science Program in Biochemical Engineering

In general, each program leading to the Master of Science degree with specialization in biochemical engineering must meet the following requirements: biochemical engineering, 18 credits; biological sciences, 12 credits; electives, 15 credits.

A thesis of at least 9 credits is required for all full-time students. (The 18 credits in biochemical engineering courses include 9 thesis credits and 9 credits in core courses.) The thesis subject may be either a fundamental or an applied problem of limited scope in the general area of biochemical engineering.

Electives may be chosen broadly from graduate course offerings with prior approval of the graduate advisor.

Curriculum

Required biochemical engineering courses		Credits
CHE 560	**Transport Phenomena in Biological Systems**	3.0
CHE 562	**Bioreactor Engineering**	3.0
CHE 564	**Unit Operations in Bioprocess Systems**	3.0

Required biological sciences courses		
BIO 500	**Biochemistry I**	3.0
BIO 610	**Biochemistry II**	3.0
BIO 520	**Cell Physiology**	3.0

Suggested electives include:

Biosciences		
BIO 649	**Recombinant DNA Laboratory**	5.0
BIO 530	**Techniques in Microbial Genetics**	3.0
BIO 615	**Experimental Biochemistry I**	3.0
BIO 618	**Experimental Biochemistry II**	3.0
BIO 620	**Biomembranes**	3.0
BIO 635	**Advanced Genetics and Molecular Biology**	3.0
BIO 660	**Microbial Physiology**	3.0
BIO 670	**Medical Microbiology**	3.0

Biomedical Engineering		
BMES 501	**Medical Sciences I**	3.0
BMES 502	**Medical Sciences II**	3.0

BMES 503	**Medical Sciences III**	3.0
BMES 521	**Principles of Bioengineering and Instrumentation I**	3.0
BMES 522	**Principles of Bioengineering and Instrumentation II**	3.0
BMES 523	**Principles of Bioengineering and Instrumentation III**	3.0
BMES 681	**Physics of Living Systems I**	3.0
BMES 682	**Physics of Living Systems II**	3.0
BMES 683	**Physics of Living Systems III**	3.0

Chemical Engineering

The graduate program in the Chemical and Biological Engineering Department integrates current chemical engineering science with the growing fields of engineering applications and processes. In emphasizing engineering design, as well as scientific analysis, the department intends to develop broadly educated individuals who are knowledgeable in modern theories, cognizant of the behavior of engineering systems, and aware of current mathematical and engineering tools that are useful for the solution of problems in complex processes and systems, especially those in the fields of chemical, environmental, biochemical, and materials process engineering.

Two major areas of specialization are available: chemical engineering and biochemical engineering.

Programs are arranged to meet the needs and interests of individual students. The plan of study is initially formulated in consultation with the departmental graduate advisor and subsequently guided by the thesis advisor.

Graduates have pursued a variety of careers, ranging from faculty positions in academia to research and development in industry, in the U.S. and overseas.

For more information, visit the Chemical and Biological Engineering Department web page.

Master of Science Program in Chemical Engineering

In general, each program leading to the Master of Science in Chemical Engineering must meet the following requirements: chemical engineering, 24 credits; area of concentration, 15 credits; electives, 6 credits.

The 24 credits in chemical engineering include 15 credits of core courses (described below) and 9 credits of thesis research. The 9-credit thesis research can be replaced with (a) 6 credits of independent study and 3 credits in the area of concentration; or (b) 9 credits in the area of concentration.

The thesis may be based on either a theoretical or an experimental investigation, or both, of limited scope but involving a significant degree of originality. The nature of the research may involve multidisciplinary areas such as environmental engineering, biomedical engineering, ceramic processing, molten metals processing, and other topics.

Courses in an area of concentration enable students to develop expertise in a technology area closely related to chemical engineering, such as environmental engineering, biochemical engineering, and materials engineering. Those contemplating a career in management of technology may consider the area of concentration in engineering management. Concentration in computer science is suggested for students interested in computer applications in chemical engineering. The courses listed under each area of concentration are recommended for students who have no prior exposure to that field. Students who have prior experience in a field should select courses in consultation with the graduate advisor.

Electives may be chosen from course offerings in chemical engineering, mathematics, science, and other engineering disciplines, subject to approval.

Full-time students usually take the core courses in the first year. Other courses may be substituted for the core courses, if equivalent courses are available and if the substitution is approved by the graduate advisor.

Seminars, attended by all full-time students and faculty, provide a forum for the discussion of original research problems and other topics of interest to chemical engineers.

Full-time students normally require a minimum of one calendar year to complete their study and research.

Some courses are offered in the late afternoon or evening for the convenience of part-time students. Programs are developed on an individual basis.

Non-chemical engineering electives, other than those listed above, require prior approval by the graduate advisor. The current schedule of evening courses and a brochure for part-time students are available upon request.

Curriculum

Five of the following courses:		15.0 Credits
CHE 502	Mathematical Methods in Chemical Engineering	3.0
CHE 513	Chemical Engineering Thermodynamics	3.0
CHE 525	Transport Phenomena I	3.0
CHE 543	Kinetics and Catalysis I	3.0
CHE 554	Process Systems Engineering	3.0
CHE 658	Advanced Process Design	3.0
	Area of concentration	15.0
	Thesis	9.0
	Electives	6.0

Sample areas of Concentration:

Biochemical Engineering

Courses		Credits
BIO 500	Biochemistry I	3.0
BIO 501	Biochemistry I Laboratory	2.0
BIO 610	Biochemistry II	3.0
CHE 560	Transport Phenomena in Biological Systems	3.0
CHE 562	Bioreactor Engineering	3.0
CHE 564	Unit Operations in Bioprocess Systems	3.0

Computer Science

Courses		Credits
CS 557	Data Structures	3.0
CS 558	Analysis of Algorithms	3.0
CS 559	Formal Language Theory	3.0
CS 720	Operating Systems I	3.0
CS 761	Compiler Construction I	3.0

Engineering Management

Courses		Credits
EGMT 501	Engineering Management I	3.0
EGMT 502	Engineering Management II	3.0
EGMT 504	Communications	3.0
EGMT 531	Economics for Engineering Management	3.0
EGMT 581	Problems in Human Relations	3.0

Environmental Engineering

Courses		Credits
ENVR 501	Chemistry of the Environment	3.0
ENVR 608	Fate of Pollutants in Air and Water	3.0
ENVE 661	Environmental Engineering Unit Operations — Chemical and Physical	3.0
ENVE 662	Environmental Engineering Unit Operations — Biological	3.0
ENVR 865	Special Topics: Environmental Engineering	3.0

Materials Engineering

Courses		Credits
MATE 500	Structure and Properties of Metals	3.0
MATE 501	Structure and Properties of Polymers	3.0
MATE 502	Structure and Properties of Ceramic and Electronic Materials	3.0
MATE 505	Phase Equilibria	3.0
MATE 506	Diffusion	3.0

Doctoral Program in Chemical Engineering

Superior students with M.S. or B.S. degrees will be considered for the doctoral program in chemical engineering.

All students are expected to develop competence in their areas of specialization. All students are urged to select a thesis topic and supervisor early in the program. A student becomes a Ph.D. candidate upon passing the candidacy examination, which includes writing and defending a research proposal; a doctoral committee is formed to direct his or her research and other aspects of the program of study.

As the culmination of intensive study and independent research, the doctoral dissertation represents a major scholarly endeavor; accordingly, it is recognized as the most important requirement of the degree. All doctoral candidates must present an acceptable dissertation based on significant work. The dissertation must represent a unique contribution to chemical engineering or biochemical engineering knowledge. A final oral examination is conducted, in part, as a defense of the dissertation.

Course Requirements

- 15 credit hours of core chemical engineering graduate courses (CHE 502, CHE 513, CHE 525, CHE 543, CHE 554)
- 15 credit hours of courses from Specialized Ph.D. Plan of Study (15 credit hours of courses approved by research and graduate program advisors)
- 60 credit hours of research and/or electives

Students joining with a Master's degree may satisfy up to 45 credit hours of the Ph. D. course/research credit requirements depending on the courses taken and/or research carried out in their Master's programs, subject to approval by graduate program advisor.

For more information, visit the Chemical and Biological Engineering Department web page.

Civil Engineering

Program Objectives
The graduate program in civil engineering offers students the opportunity to develop a more fundamental and complete understanding of the principles that govern their field as well as current design methodology. Students are encouraged to be innovative and imaginative in their quest for recognizing, stating, analyzing, and solving engineering problems.

The goal of the master's program is to develop technical depth of expertise for a professional career in the planning, design, construction, and operation of large-scale infrastructure systems, built facilities, and water resources management. The goal of the Ph.D. program is to develop the abilities to discover, pursue, and apply basic knowledge. Ph.D. recipients are prepared to engage in teaching and research or in an industrial career in the development of new concepts and innovative systems.

General Information
The civil engineering programs comprise the following areas of specialization: building systems, geotechnical engineering, hydraulic and coastal engineering, structural engineering, and water resources.

For more information, visit the Department of Civil, Architectural and Environmental Engineering web page.

Master of Science Program in Civil Engineering

The programs of study at the master's level continue the specialization developed at the senior level of the undergraduate program or newly developed interests. The Master of Science in Civil Engineering degree may be elected by graduates of ABET-accredited undergraduate programs in civil engineering and related fields. Admission and prerequisites are determined on the basis of a student's undergraduate transcript.

Most M.S.C.E. graduates work as professional engineers in consulting firms, industry, or governmental agencies. A number of our graduates have started consulting and construction firms in the Philadelphia area and have been very successful. Other former students hold prominent positions in public utilities, local government agencies, and industry.

The full-time graduate academic program is closely associated with the research efforts of the faculty. Full-time master's degree candidates are encouraged to base their master's thesis on some aspect of faculty research. The one-to-one relationship between student and faculty member provides an invaluable learning experience. The General (Aptitude) Test of the Graduate Record Examination (GRE) is required for applicants pursuing full-time study.

The master's degree requires a total of 45 credits, of which 24 credits must be in the major field of interest and 6 credits are to fulfill math requirements. The remaining credits are taken as electives in related areas. The choice of core and elective courses is made in consultation with the student's graduate advisor.

Areas of concentration include:

- Structural
- Geotechnical/geoenvironmental
- Water resources/coastal
- Building systems/energy
- Geosynthetics
- Infrastructure materials

Dual graduate degrees are possible. Among the more popular programs are combining the M.S. in Civil Engineering with an M.S. in Environmental Engineering, or Engineering Management. The required credits must meet all civil engineering program requirements and will be determined on the basis of the student's proposed program of study.

Doctoral Program in Civil Engineering

Doctoral Program
The Ph.D. degree is awarded for original research on a significant civil engineering problem. Graduate students who have completed their M.S. degrees work closely with individual faculty members (see Faculty Research Interests below). Ph.D. dissertation research is usually supported by a research grant from a government agency or an industrial contract.

Doctoral students normally take at least 45 credits, including research credits, beyond the master's degree requirements. Full-time residency for one continuous academic year is required for the Ph.D. degree to ensure students the opportunity for intellectual association with other scholars. Many doctoral students take two, three, or four years of full-time graduate study to complete their degrees. Involvement in the teaching activity of the Civil, Architectural and Environmental Engineering Department is required of all Ph.D. applicants.

After approximately one year of study beyond the master's degree, doctoral students take a qualifying examination, consisting of written and oral parts. Each Ph.D. candidate is supervised by a major professor and a doctoral committee chaired by the major professor.

Ph.D. candidates submit a detailed proposal for dissertation research to the doctoral committee. The students then take a candidacy examination; successful completion of this examination is required to become a Ph.D candidate. After approval of the proposal, the committee meets from time to time to review the progress of the research. The dissertation must be submitted to the doctoral committee at least 90 days before the graduation date. The committee schedules and conducts a final oral examination before approval of the dissertation.

Ph.D. graduates find positions in

- Universities
- Consulting engineering
- Industrial or government research
- Public operating agencies

Computer Science

The Master of Science in Computer Science
The Master of Science in Computer Science is designed to provide breadth of understanding in the core topics of computer science, in-depth advanced material, and a range of topics courses in the research areas of the faculty. A balance of theory and practice is presented preparing students to perform cutting edge research as well as training students to become practicing computational scientists, computer specialists or software engineers in business, industry or government. A thesis option is available to prepare students for doctoral studies or other research-oriented career paths.

The Doctorate in Computer Science
Students enrolled in the Ph.D. program are expected to acquire broad knowledge in all areas of computer science and an overall perspective of the field, its structure, and its problems. They are expected to study at least one subfield in considerable depth, and to make substantial contributions to that subfield through creative research and serious scholarship. The program is designed for students to advance their basic understanding of information processes and to contribute to the creation and consolidation of knowledge in computer science. In addition, they should be able to see and understand new problems between different areas within computer science, as well as between computer science and other fields, and to find and implement imaginative solutions.

The Doctorate in Computer Science is structured to serve both full and part-time students.

For more information, visit the Department of Computer Science web site.

M.S. in Computer Science

45.0 Credits

General Requirements

Students must complete a minimum of 45 graduate credits for the M.S. degree. All students are required to submit a plan of study form with the Graduate Advisor at the beginning of their studies. Significant changes to the plan of study should be discussed with the Graduate Advisor.

Precore Classes

Precore classes are graduate level courses, but are not considered graduate level CS courses. These courses only count towards the degree requirement listed below for "three additional graduate level courses." Precore courses are intended for students without adequate CS background. The material in these courses is considered prerequisite knowledge for all other graduate CS courses.

- CS 520 Foundations of Computer Science
- CS 570 Programming Tools and Environments

Degree Requirements

Core Courses		Credits
CS 521	**Data Structures and Algorithms I**	3.0
CS 522	**Data Structures and Algorithms II**	3.0
CS 525	**Theory of Computation**	3.0
CS 550	**Programming Languages**	3.0
CS 543	**Operating Systems**	3.0
CS 544	**Computer Networks**	3.0

Computer Science Breadth Requirement

Students select three intermediate courses, from at least two areas, from the following list:

Note: Some special topics courses (CS 680) may also count towards the breadth requirement. Contact the Graduate Advisor for more information.

Algorithms and Theory		
CS 621	**Approximation Algorithms**	3.0
CS 622	**Complexity and Computability**	3.0
CS 623	**Computational Geometry**	3.0

Artificial Intelligence and Robotics

CS 510	**Artificial Intelligence**	3.0
CS 511	**Robot Building Lab**	3.0
CS 610	**Advanced Artificial Intelligence**	3.0
CS 612	**Knowledge Based Agents**	3.0
CS 613	**Machine Learning**	3.0
CS 615	**Intelligent Time-Critical Systems**	3.0

Computer Architecture

ECEC 621	**Applied Computer Architecture I (High-performance Computer Architecture)**	3.0
ECEC 622	**Applied Computer Architecture II (Parallel Computer Architecture)**	3.0

Human Computer Interaction and Computer Graphics

CS 536	**Computer Graphics**	3.0
CS 530	**Developing User Interfaces**	3.0

Numeric and Symbolic Computation

CS 567	**Applied Symbolic Computation**	3.0
CS 668	**Computer Algebra I**	3.0
CS 660	**Numerical Computing**	3.0
CS 661	**Numerical Analysis I**	3.0

Programming Languages and Compilers

CS 551	**Compiler Construction I**	3.0
CS 552	**Compiler Construction II**	3.0

Software Engineering

CS 575	**Software Design**	3.0
CS 576	**Dependable Software Systems**	3.0

Systems

CS 643	**Advanced Operating Systems**	3.0
CS 644	**Computer Networks II**	3.0
ECEC 632	**Computer Network Design II**	3.0
CS 500	**Database Theory**	3.0

Computer Science Depth Requirement

Depth requirement courses should build on basic material obtained from the breadth requirement courses, from the research articles, and include a research project. Some special topics courses (CS680) or advanced seminars (e.g. CS 729) may also count towards the depth requirement. Contact the Graduate Advisor for further information about particular courses.

Students select one advanced course from the following:

CS 646	**Operating Systems Workshop**	3.0

CS 676	**Parallel Processing**	3.0
CS 645	**Cryptography and Network Security**	3.0
CS 669	**Computer Algebra II**	3.0
CS 662	**Numerical Analysis II**	3.0
CS 675	**Reverse Software Engineering**	3.0
CS 636	**Advanced Computer Graphics**	3.0
CS 630	**Cognitive Systems**	3.0
ECEC 623	**Applied Computer Architecture III (Advanced Parallel Computer Architecture)**	3.0
ECEC 633	**Computer Network Design III (Advanced Topics in Computer Networks)**	3.0

Thesis Option
Usually students pursuing a Master's Thesis will first do 3 research credits (CS 897 or CS 997) to obtain background knowledge required by the thesis topic. It is the responsibility of the student to find a thesis supervisor.

CS 898	**Master's Thesis**	6.0

Non-thesis Option
The non-thesis option requires two additional courses from either intermediate level or advanced level courses listed above.

Three additional graduate level courses are required:

These courses may come from either intermediate or advanced courses. In addition, courses may be taken outside the department, may include CS 897 (Independent Study), CS 997 (Research in Computer Science), and precore Computer Science courses listed in requirement (0). Any course not explicitly listed above, including independent study and research courses, must be approved by the Graduate Advisor.

Other courses, such as special topics, the department offers may qualify for meeting intermediate or advanced requirements. Students must check with the department to see if this is the case. Any course offered by other departments not listed here must be approved by the Graduate Advisor, or they will not count towards the degree.

Ph.D. in Computer Science

90.0 credits

General Requirements

The following general requirements must be satisfied in order to complete the Ph.D. in Computer Science:

- 90.0 credit hours total
- 10 breadth requirement courses
- 3 advanced courses, plus 3 additional independent study courses (approved by student's advisor) toward the depth requirement
- qualifying exam
- candidacy exam
- approval of dissertation proposal
- defense of dissertation

Students entering with a master's degree may be exempted from some or all of the courses in the breadth requirement; however, they are still required to take and pass the qualifying exam. In addition students may receive up to 45 transfer credits for an existing M.S. degree in Computer Science or related field. Individual courses may also be transferred with approval of the Graduate Advisor.
The total credit amount, candidacy exam, and dissertation are University Requirements. Additional requirements are determined by the department offering the degree.

Curriculum

Breadth Requirement Courses		Credits
CS 521	**Data Structures and Algorithms I**	3.0
CS 522	**Data Structures and Algorithms II**	3.0
CS 525	**Theory of Computation**	3.0
CS 550	**Programming Languages**	3.0
CS 543	**Operating Systems**	3.0
CS 544	**Computer Networks**	3.0

In addition, all students are required to take an additional four courses and develop background knowledge in an area of particular interest. These courses are organized into the following seven areas. Students must take courses from at least two different areas:

Artificial Intelligence		
CS 510	**Artificial Intelligence**	3.0
CS 610	**Advanced Artificial Intelligence**	3.0

CS 612	**Knowledge Based Agents**	3.0
CS 613	**Machine Learning**	3.0
CS 614	**Natural Language Processing**	3.0
CS 615	**Intelligent Time-Critical Reasoning**	3.0

Algorithms and Theory

CS 621	**Approximation Algorithms**	3.0
CS 623	**Computational Geometry**	3.0
CS 759	**Complexity Theory**	3.0
CS 680	**Special Topics: Parallel Algorithms**	3.0
CS 680	**Special Topics: Topics in Algorithms**	3.0

Human Computer Interaction and Computer Graphics

CS 530	**Developing User Interfaces**	3.0
CS 536	**Computer Graphics**	3.0
CS 630	**\Cognitive Modeling**	3.0
CS 636	**Advanced Computer Graphics**	3.0
PSY 612	**Psychology of Human-Computer Interaction**	3.0

Numeric and Symbolic Computation

CS 680 / MATH 540	**Numeric Computing**	3.0
CS 680 / MATH 521	**Numerical Analysis II**	3.0
CS 680 / MATH 522	**Numerical Analysis III**	3.0
CS 567	**Applied Symbolic Computation**	3.0
CS 668	**Computer Algebra I**	3.0
CS 669	**Computer Algebra II**	3.0

Programming Languages and Compilers

CS 551	**Compiler Construction I**	3.0
CS 552	**Compiler Construction II**	3.0

Software Engineering

CS 575	**Software Design**	3.0
CS 576	**Dependable Software Systems**	3.0
CS 675	**Reverse Engineering**	3.0
CS 680	**Special Topics: Formal Methods**	3.0

Systems

CS 643	**Advanced Operating Systems**	3.0
CS 644	**Computer Networks II**	3.0
CS 645	**Network Security**	3.0
CS 676	**Parallel Processing**	3.0

Depth Requirement Courses

Doctoral students are required to complete at least three CS courses beyond the breadth requirement. These courses should be advanced courses listed in the areas under the breadth requirement, appropriate special topics courses, or advanced topics courses covering current research in selected areas. All students must take at least one advanced topics course. Course selection must be made with the student's advisor.

Independent Study Courses

Students are required to take 9 additional credits of independent study work. Selection of independent studies should be made in consultation with the student's advisor. This work is intended to prepare the student for later research.

Thesis Proposal

After completing the candidacy examination successfully, the Ph.D. candidate must prepare a thesis proposal that outlines, in detail, the specific problems that will be solved in the Ph.D. dissertation. The quality of the research proposal should be at the level of, for example, a peer-reviewed proposal to a federal funding agency, or a publishable scientific paper. The candidate is responsible for sending the research proposal to the Ph.D. committee two weeks before the oral presentation. The Ph.D. committee need not be the same as the candidacy exam committee, but it follows the same requirements and must be approved by the Office of Graduate Studies. The oral presentation involves a 30-minute presentation by the candidate followed by an unspecified period during which the committee will ask questions.

After the question and answer period, the candidate will be asked to leave the room and the committee will determine if the research proposal has been accepted. The research proposal can be repeated at most once. A thesis proposal must be approved within two years of becoming a Ph.D. candidate.

Thesis Defense

After completing the research proposal successfully, the Ph.D. candidate must conduct the necessary research and publish the results in a Ph.D. dissertation. The dissertation must be submitted to the Ph.D. committee two weeks prior to the oral defense. The oral presentation involves a 45-minute presentation by the candidate, open to the public, followed by an unspecified period during which the committee will ask questions. The question-and-answer period is not open to the public. After the question and answer period, the candidate will be asked to leave the room and the committee will determine if the candidate has passed or failed the examination. The candidate will be granted one more chance to pass the final defense if (s)he fails it the first time. Paperwork selecting the thesis committee and indicating the results of the thesis defense must be filed with the Department and the Office of Graduate Studies.

Dual M.S. Degree in Mathematics and Computer Science

Students with interest and strong backgrounds in both mathematics and computer science are encouraged to pursue a dual degree in mathematics and computer science, or to combine their studies with a field outside the department. Some popular combinations include mathematics/physics, computer science/computer engineering, computer science/biomedical engineering, and computer science/ software engineering.

Typically, this requires an additional half-year of study beyond that required for an M.S. in either field. Both degrees are awarded simultaneously upon completion of this program. The M.S. is awarded after satisfactory completion of a minimum of 45 credit hours, including 27 hours of core courses in an area of specialization. The specializations are applied mathematics, statistics and operations research, scientific computation, and computer science. Students specializing in scientific computation may earn the M.S. in either mathematics or computer science.

Electrical Engineering

General Information

The Master of Science in Electrical Engineering degree requires a minimum of 45 approved credits chosen in accordance with a plan of study arranged with the permission of a student's adviser and the departmental graduate adviser. Students who complete a six-month period of internship through Drexel's Career Integrated Education (CIE) program must complete 48 credits including 6 CIE credits.

The plan must contain a selection of core courses from the department's offerings and may include appropriate graduate courses from other engineering departments or from physics or mathematics. Further information can be obtained from the department office or from the graduate adviser.

Full-time graduate students receiving teaching or research assistantships are required to complete a master's thesis, for which up to 9 credits may be earned. Other full-time and part-time students also are encouraged to engage in thesis research. The combined thesis and research cannot exceed 9 credits.

The program is organized so that a student may complete the degree requirements in two years of full-time study or three years of part-time study.

For more information, visit the Electrical Engineering web page.

Master of Science in Electrical Engineering

A total of 45 approved graduate credits are required for the degree of Master of Science in Electrical Engineering. Appropriate courses in other graduate departments of engineering, science or mathematics may be included in these credits. However, a minimum of 30 credits must be taken in the Department of ECE to receive an MSEE. Students who participate in Career Integrated Education (CIE) must complete 48 approved credits, including 6 credits of CIE.

For more information on curriculum requirements, visit the Department of Electrical and Computer Engineering's Graduate Student Guide.

- **Please note that ECEC 500 and ECEC 600 will not count toward the 45 required credits.**

Plan of Study

Before the end of the first quarter in the ECE department, for a full-time student, or by the end of the first year for a part-time student, the student must file a plan of study with the graduate advisor.

Core Courses

Core courses present the subject matter that is basic to each curricular area. They are prerequisite to the more specialized courses. The core requirements for the various specialties are listed below:

Electrophysics

Required courses:

Students select 6 graduate courses (18 credits) from the Electrophysics course list.

Controls, Robotics, Intelligent Systems

Required courses:

Students should check with the graduate advisor regarding core requirements for this specialization.

Power Engineering

Required courses:

ECEP 501	**Power System Analysis**	3.0
ECEP 502	**Computer Analysis Power Systems**	3.0
ECEP 503	**Synchronous Machine Modeling**	3.0

Students select an additional sequence from the following:

ECES 511	**Fundamentals in Systems I**	3.0
ECES 512	**Fundamentals in Systems II**	3.0
or		
ECES 521	**Probability and Random Variables**	3.0
ECES 522	**Random Process and Spec Analysis**	3.0

Signal/Image Processing

Required courses:

ECES 510	**Analytical Methods in Systems**	3.0
ECES 521	**Probability and Random Variables***	3.0
ECES 522	**Random Process and Spec Analysis**	3.0
ECES 523	**Detection and Estimation Theory**	3.0
ECES 631	**Fundamentals of Deterministic Digital Signal Processing**	3.0
ECES 682	**Fundamentals of Image Processing**	3.0

*Students having a background in this topic will not be required to take ECES 521. Instead, students an choose another 3 credit elective course.

Computer Engineering

General Information

The Master of Science in Computer Engineering degree requires a minimum of 45 approved credits chosen in accordance with a plan of study arranged in consultation with the student's advisor and the departmental graduate advisor. Up to but not exceeding 9 research/thesis credits may be taken by students who choose to write a Master's thesis. Students who elect a non-thesis option are also encouraged to engage in research, by registering for research credits (not to exceed 9 credits).

For more information, visit the Computer Engineering web page.

Master of Science in Computer Engineering

Core Requirements
The core requirement consists of two courses, ECEC 621 (High-Performance Computer Architecture) and ECEC 631 (Principles of Computer Networking), which are the first courses of the computer architecture sequence and the networks sequence, respectively. Students must complete one of these two sequences.

Sequence Requirement
A student's plan of study must include at least one three-course sequence. At present, we have available five sequences in the areas of discrete mathematics in computer engineering, switching theory, computer architecture, networks, and embedded systems.

Credits Requirement
Students choosing the nonthesis option will be required to take 18 credits of computer engineering (ECEC) courses, 6 credits of electrical engineering (ECEE, ECES, ECEP) courses, 12 credits of engineering and/or mathematics and computer science courses, 6 credits of free ECE electives, and 3 credits of approved free electives. Those choosing the thesis option will be required to take 18 in ECEC courses, 6 credits in electrical engineering courses, 12 credits of engineering and/or mathematics and computer science courses, and 9 credits in thesis. The chart below summarizes this requirement in the M.S. in Computer Engineering plan of study.

Students may choose to participate in the College of Engineering Career Integrated Education (CIE) program, where they earn 6 academic credits for working in industry on computer engineering–related projects. The students choosing the CIE option will need a total of 48 credits for graduation.

For more information on curriculum requirements, visit the Department of Electrical and Computer Engineering's Graduate Student Guide.

Non-thesis option	
Computer engineering courses	18.0
Electrical engineering courses	6.0
Engineering and/or math/computer science courses	12.0
Electrical engineering or computer engineering electives	6.0
Approved free elective	3.0

Thesis option	
Computer engineering courses	18.0
Electrical engineering courses	6.0
Engineering and/or math/computer science courses	12.0
M.S. thesis	9.0

Computer Engineering Courses

Courses		Credits
ECEC 501	Principles of Representation and Reasoning	3.0
ECEC 502	Principles of Data Analysis and Regularity Recognition	3.0
ECEC 503	Principles of Decision Making, Planning, and Control	3.0
ECEC 511	Issues in Combinational Circuit Design	3.0
ECEC 512	Issues in Sequential Circuit Design	3.0
ECEC 513	Design for Testability	3.0
ECEC 621	High-performance Computer Architecture	3.0
ECEC 622	Parallel Computer Architectures	3.0
ECEC 623	Advanced Parallel Computer Architectures	3.0
ECEC 631	Principles of Computer Networking	3.0
ECEC 632	Performance Analysis of Computer Networks	3.0
ECEC 633	Advanced Topics in Computer Networks	3.0
ECEC 661	VLSI Design	3.0
ECEC 662	Design for Synthesis, Testability, and Performance Modeling	3.0
ECEC 663	VLSI Array Processors	3.0

Please note that ECEC 500 and ECEC 600 will not count towards the required 45 credits.

Telecommunications Engineering

General Information

Fueled by the rapid spread of technologies such as electronic mail, cellular and mobile phone systems, interactive cable television, and the information superhighway, Drexel's program in Telecommunications Engineering responds to the growing demand for engineers with telecommunications expertise.

Drexel University's program in Telecommunications Engineering combines the expertise of its faculty in Electrical and Computer Engineering, Business, Information Systems, and Humanities. The program combines a strong foundation in telecommunications engineering with training in other important areas such as global communications, business aspects of telecommunications, and information transfer and processing. Through its interdisciplinary approach, Drexel's Telecommunications Engineering program trains and nurtures the complete telecommunications engineer.

Program of Study

The MSEE/Telecommunications Engineering degree is awarded to students who demonstrate in-depth knowledge of the field. All students will complete either a project in telecommunications or a six month period of internship through Drexel's Career Integrated Education (CIE) program. The average time required to complete the master's degree is two year of full-time or three years of part-time study.

For more information, visit the Telecommunications Engineering web page.

Telecommunications Engineering

Program of Study
The M.S.E.E./Telecommunications Engineering degree is awarded to students who demonstrate in-depth knowledge of the field. The average time required to complete the master's degree is two years of full-time study or three years of part-time study.

The curriculum emphasizes both the engineering and non-engineering aspects of Telecommunications engineering, and features industry participation through Career-Integrated Education (CIE) programs where students, national and international, interact with industries and businesses dealing with telecommunications.

Degree Requirements
The M.S.E.E./Telecommunications Engineering curriculum encompasses 45 or 48 credits (with the CIE option).

Students must complete 21 core credits in telecommunications. Appropriate courses in other graduate departments of engineering, science or mathematics may be taken as electives. However, a minimum of 30 credits must be taken in the Department of ECE to receive an M.S.E.E.T. No more than 15 quarter credits may be transferred from other institutions or other departments. These must be graduate courses which earned a grade of B or A and which were not used to earn a previous degree. Transfer credits must be approved by the ECE graduate advisor.

For more information on curriculum requirements, visit the Department of Electrical and Computer Engineering's Graduate Student Guide.

Engineering

Required Core Courses		Credits
ECES 521	**Probability and Random Variables**	3.0
ECES 522	**Random Process and Spec Analysis**	3.0
ECEC 631	**Principles of Computer Networking**	3.0
ECET 501	**Fundamentals of Communications Engineering**	3.0
ECET 511	**Physical Foundations of Telecommunications Networks**	3.0
ECET 512	**Wireless Systems**	3.0
ECET 513	**Wireless Networks**	3.0

Non-Engineering:
The following courses dealing with the business and legal aspects of telecommunications are strongly recommended to students pursuing the major:

COM 650	**Telecommunications Policy**	3.0
MIS 620	**Telecommunications Management**	3.0

Suggested Electives

The following list contains suggested electives from the graduate offerings in the Electrical & Computer Engineering Department. These courses allow students to choose specific tracks. Students may also select other elective courses from the ECE Graduate menu.

ECES 631	**Fundamentals of Deterministic Digital Signal Processing**	3.0
ECEE 517	**Microwave Networks and Transmission Media**	3.0
ECEE 641	**Fiber Optics and Optical Communications I**	3.0
ECEE 522	**Photonic Devices**	3.0
ECEC 661	**VLSI Design**	3.0
ECEC 631	**Principles of Computer Networking**	3.0

Please note that ECEC 500 and ECEC 600 will not count towards the 45 required credits.

Electrical and Computer Engineering

Ph.D. Programs
Superior students will be considered for the program leading to the degree of Doctor of Philosophy. The program of study is individually arranged, under the supervision of a faculty advisor.

All Ph.D. applicants are required to participate in teaching, research, and the Electrical and Computer Engineering Department seminar program.

The department's offerings are focused on six general areas: Computer Engineering, Controls, Robotics & Intelligent Systems, Electrophysics, Image & Signal Processing, Power Engineering, and Telecommunications & Networking.

For more information on Ph.D. program requirements, visit the Department of Electrical and Computer Engineering's Graduate Student Guide.

Engineering Management

General Information
In our increasingly complex, technologically oriented economy, demand has risen for professionals with the expertise to manage both human and technological resources — a combination of talents crucial to organizations competing in the global marketplace. Students graduating with the M.S. in engineering management are significantly better positioned to meet the new challenge.

Engineering Management is a multidisciplinary program offering a core curriculum and specialization in a selected area of technology or management. Study can be on a part-time or full-time basis, and all courses are offered in the evening. Majors in engineering management must hold a bachelor's degree in engineering, basic science, or a related field. The program is open to those professionals who aspire to be engineering or technically based managers.

For more detailed informatoin on the program, visit the Engineering Management home page.

Dual-Degree Requirements
Students may simultaneously pursue the M.S. in engineering management and another M.S. degree. Students must satisfy program requirements for each degree, with a maximum of 15 credits transferred from one program to the other. (The M.S. in engineering management requires 48 credits; if the other degree requires 45 credits, then 63 credits are required under the dual degree program.) Approval for the dual degree program must be obtained from the program advisor in each department.

Career Integrated Education Program
The Career Integrated Education program (graduate intern or co-op program) is available to master's-level engineering management students. The opportunity to spend six months in industry provides a significant opportunity for the engineer in transition to management. Through Drexel's Steinbright Career Development Center, students can explore new career directions. This program requires 6 additional credits, 3 for each term in industry.

Master of Science Program in Engineering Management

Degree Requirements

The M.S. degree requires 48 credits, including 33 credits in required core courses and 15 graduate elective credits, of which 6 or more credits are in a major area of interest. These electives may be taken in other colleges at Drexel consistent with the plan of study and any required prerequisites. Typical elective areas of specialization are listed below.

Students with a particular interest in technology or management who can satisfy the prerequisite and departmental requirements are free to select any 6- to 15-credit sequence with the approval of the program director. Alternatively, students may take the balance of required elective credits from any other graduate-level course(s) in engineering, business, or another college for which they have adequate preparation and can obtain approvals from the college and the Engineering Management program.

All candidates are urged to discuss their areas of interest with the program director and to develop a proposed plan of study during the early stages of their program.

Curriculum

Core courses	Credits
Engineering Management	
EGMT 501 **Engineering Management I**	3.0
EGMT 502 **Engineering Management II**	3.0
EGMT 504 **Communications**	3.0
EGMT 581 **Problems in Human Relations**	3.0
Finance & Business Policy	
EGMT 531 **Economics for Engineering Management**	3.0
EGMT 535 **Financial Management I**	3.0
EGMT 536 **Financial Management II**	3.0
EGMT 537 **Problems in Engineering Administration**	3.0
Quantitative Analysis	
EGMT 571 **Managerial Statistics I**	3.0
EGMT 572 **Managerial Statistics II***	3.0
EGMT 573 **Operations Research I**	3.0
EGMT 574 **Operations Research II**	3.0

*EGMT 572 requires as a prerequisite EGMT 571 (Managerial Statistics I) or permission of the instructor. Students may take EGMT 571, but credit for it is not applicable to the degree. EGMT 571 is offered in the summer term.

Note: Specific course requirements will be waived for students who have taken equivalent courses elsewhere.

Electives	Credits
EGMT 607 **Marketing for Engineeing Management**	3.0
EGMT 652 **Engineering Law**	3.0
EGMT 605 **R&D Management I**	3.0
EGMT 606 **R&D Management II**	3.0
EGMT 680 **Six Sigma Planning for Engineers**	3.0
EGMT 680 **Special Topics: Project Management for Engineers**	3.0
EGMT 680 **Special Topics: Systems Methods**	3.0
EGMT 680 **Special Topics: Business Ethics for Engineers**	3.0
EGMT 680 **Special Topics: Leadership in Engineering Management**	3.0
EGMT 680 **Special Topics: Preventing Technological Disasters**	3.0

Engineering Management on the Web

The engineering management program offers courses from the regular curriculum over the Internet. Students can currently obtain a Graduate Certificate and their master's degree by attending classes on the web. Though the instructor follows the on-campus schedule for the lecture material, homework, projects, and examinations, students have some flexibility in receiving lecture material and scheduling their time.

For more information about the program please visit the Drexel eLearning Engineering Management page.

Environmental Engineering

Environmental engineering is concerned with protecting human, animal, and plant populations from the effects of adverse environmental factors, including toxic chemicals and wastes, pathogenic bacteria, and global warming.

Environmental engineers also try to minimize the effect of human activities on the physical and living environment so that we can all live more healthy lives.This field builds on other branches of engineering, especially civil, chemical, and mechanical engineering. It also builds on information from many of the sciences, such as chemistry, physics, hydrology, geology, atmospheric science, and several specializations of biology (ecology, microbiology) and public health. Students who elect to study environmental engineering will become familiar with many of these areas because maintaining and improving the environment requires that problems be evaluated and solutions found using a multidisciplinary approach.

For more information about this program, visit the M.S. in Environmental Engineering web page.

Master of Science in Environmental Engineering

The M.S. in Environmental Engineering requires 45 credits (thesis option) or 48 credits (non-thesis option). It is possible to finish the M.S. degree on either a part-time or a full-time basis. The degree consists of five core courses (chemistry, statistics, analysis of physical systems, and policy), completion of sequences in two areas (water and wastewater, air pollution control, hazardous waste, chemodynamics, assessment, or water resources), additional elective courses and/or the M.S. thesis. Full time students can complete the degree in 15-18 months.

Ph.D. Program in Environmental Engineering

Applicants to the doctoral program are judged on the basis of academic excellence and the alignment of their research interests with those of the faculty in the School. To be awarded the Ph.D., students must complete a major research project publishable in a peer-reviewed journal. The degree requires a total of 90 credits; credits earned toward a master's degree may apply toward the 90. There is no prescribed coursework—students must take courses needed to complete their research under guidance of an academic advisor. There is a one-year residency requirement. Students must successfully pass the qualifying examination, the candidacy examination, and a Ph.D. dissertation and oral defense.

Prospective Ph.D. student are welcome to contact the School to discuss their research interests.

Master of Engineering

General Information

The Master of Engineering with a practice-oriented manufacturing option, a multidisciplinary program, draws on the strengths of all the departments in the College of Engineering, as well as on the offerings of related areas within the University. Intense global competition has created a demand in American industry for engineering professionals with expertise in modern manufacturing technology, including both the management and physical aspects of manufacturing. The M.E. degree program with a practice-oriented manufacturing option is designed for working professionals and those seeking employment in a manufacturing-related industry.

The M.E. program offers wide flexibility for those students who wish to combine technical and nontechnical study with hands-on experience in industry. It is a career-focused program and may not be appropriate for those whose ultimate goal is a Ph.D. in engineering.

Master of Engineering

Program of Study

All students enrolled in the program receive the M.E. degree from the College of Engineering. Students take a series of manufacturing core courses, a set of discipline-oriented engineering courses, business core electives, and a mathematics/quantitative methods course. A six-month period of career-related employment through Drexel's Career Integrated Education (CIE) program is a requirement for full-time students. Students who are already employed as practicing engineers may apply to pursue the program on a part-time basis. A thesis is not required. The average time required to complete the master's degree is two years of full-time study or three years of part-time study.

Degree Requirements

The degree requires a total of 48 credits, including at least 18 credits from an engineering discipline core. This core may be from any engineering department: Civil and Architectural, Chemical, Electrical and Computer, Materials, or Mechanical Engineering and Mechanics. (Please refer to the appropriate departmental description in this catalog for more information about each department.) Students also complete 15 credits from the manufacturing core, which includes 6 credits in manufacturing and 9 credits of departmental manufacturing electives. Three credits of either engineering analysis or probability and statistics, 6 credits from either engineering management or the Bennett S. LeBow College of Business, and 6 credits of CIE round out the program.

Curriculum

Manufacturing core courses		Credits
MEM 687	**Manufacturing Processes I**	3.0
MEM 689	**Computer-Aided Manufacturing**	3.0
	Departmental manufacturing electives (see below)	9.0
	Departmental engineering core	18.0
	Engineering management/business requirements (see below)	6.0
	Engineering analysis/probability and statistics requirement	3.0
	CIE	6.0

Departmental Manufacturing Elective Courses

At least three of the following courses must be completed:

Chemical Engineering

Courses		Credits
CHE 525	**Transport Phenomena I**	3.0

CHE 554	**Process Systems Engineering**	3.0
CHE 560	**Transport Phenomena in Biological Systems**	3.0
CHE 562	**Bioreactor Engineering**	3.0
CHE 564	**Unit Operations in Bioprocess Systems**	3.0

Civil Engineering

Courses		Credits
CIVE 673	**Construction Project Management**	3.0
CIVE 674	**Construction Contracting I**	3.0
CIVE 770	**Construction Process Modeling I**	3.0
CIVE 771	**Construction Process Modeling II**	3.0
CIVE 773	**Construction Management**	3.0

Electrical and Computer Engineering

Courses		Credits
ECEC 541	**Robotics/Computer Interface and Controls I**	3.0
ECEC 542	**Robotics/Computer Interface and Controls II**	3.0

Materials Engineering

Courses		Credits
MATE 570	**Materials Processing**	3.0
MATE 651	**Advanced Polymer Processing**	3.0

Mechanical Engineering and Mechanics

Courses		Credits
MEM 688	**Manufacturing Processes II**	3.0
MEM 717	**Heat Transfer in Manufacturing Processes**	3.0
MEM 727	**Fluid Dynamics in Manufacturing Processes**	3.0
MEM 772	**Plasticity in Manufacturing**	3.0
MEM 800	**Special Topics: Concurrent Engineering I**	3.0
MEM 800	**Special Topics: Concurrent Engineering II**	3.0
MEM 800	**Special Topics: Engineering Finite Element Analysis**	3.0

Business Core

At least two of the following courses must be completed:

LeBow College of Business

Courses		Credits
POM 620	**Management of Manufacturing Firms**	3.0
POM 624	**Management of Service Firms**	3.0

Engineering Management

Courses		Credits
EGMT 531	**Economics for Engineering Management**	3.0
EGMT 607	**Marketing for Engineers**	3.0
EGMT 652	**Engineering Law**	3.0
EGMT 680	**Manufacturing Management for Engineers**	3.0

Materials Engineering

General information
The graduate program in Materials Engineering aims to provide an education which encompasses both the breadth and depth of the most recent knowledge base in the Materials Engineering field in a format suitable for individuals seeking careers in education and/or industry.

In addition, the program provides students with research training through their course of thesis research at the M.S. and Ph.D. levels.

The graduate student body reflects a broad spectrum of undergraduate backgrounds. Students with undergraduate degrees in engineering fields, other than materials science, are encouraged to take selected undergraduate courses in materials. Because of the expansion into interdisciplinary areas, qualified physical and biological science graduates may also join the program. However, nonengineering graduates must take an appropriate number of undergraduate engineering courses to supplement their background.

Graduate work in materials engineering is offered both on a regular full-time basis and on a part-time basis. The General (Aptitude) Test of the Graduate Record Examination (GRE) is required for applicants pursuing full-time study.

A graduate seminar is required of all graduate students in the department. The seminar, which should be completed during the first year of the program, consists of an oral presentation based on a completed literature review of topics closely related to the student's potential research area.

Career Opportunities
Graduates go on to careers in engineering firms, consulting firms, private industry, research laboratories, academia, and government. Materials engineers find employment in such organizations as Hewlett-Packard, Intel, IBM, 3M, Lockheed-Martin, Xerox, Motorola, Monsanto, Corning, and Eastman Kodak.

For more information about Materials Engineering, visit the Materials Engineering Department web page.

Master of Science Program in Materials Engineering

A total of 45 credits is required for the M.S. degree. These include five required core courses on the structure and properties of metals, polymers, and ceramic and electronic materials; the thermodynamics of solids; and the mechanical behavior of solids.

A 3-credit course from the Department of Mathematics and Computer Science or the course in numerical methods (MATE 580), offered by the Department of Materials Engineering, fulfills the math requirement.

All full-time students are required to undertake a 9-credit thesis on a topic of materials research supervised by a faculty member and to submit a plan of study during their first year of the program. Part-time graduate students are encouraged to undertake a research thesis, but if this is not possible, a faculty-supervised 6-credit literature survey (involving a research proposal) is required.

All students are required, during their first year, to propose an advisor-supported research thesis topic or literature survey for approval by the department. Students are urged to make a choice of topic as early as possible and to choose appropriate graduate courses in consultation with their advisor. Both the research thesis and the literature survey are subject to an oral examination before the M.S. degree is awarded.

The program is organized so that part-time students may complete the degree requirements in two to four years. Full-time students may complete the program in two years.

Doctoral Program in Materials Engineering

The graduate school requires at least 90 credits for the Ph.D. degree. An M.S. degree is not a prerequisite for the Ph.D. degree, but does count as 45 credits toward the 90-credit requirement. No additional courses are required for students entering the department with an M.S. degree. Students entering the department at the B.S. level must satisfy the course requirements for the M.S. degree.

Students choose a doctoral thesis topic after consultation with the faculty. Students are urged to consider topics early in the program. An oral thesis presentation and defense is scheduled at the completion of the thesis work.

In addition to the graduate seminar required of all graduate students, doctoral program students must pass a candidacy examination. This consists of two parts, a written part and an oral part. The written part consists of a four-hour examination covering the materials core course, and a four-hour examination in a specific subject area selected by the student in consultation with his or her faculty advisor and subject to approval by the department's graduate committee.

For more information, visit the Materials Engineering Department web page.

Mechanical Engineering and Mechanics

General Information
The field of mechanical engineering is rapidly changing due to advances in materials, manufacturing, and communication. Mechanical engineers must possess diverse interdisciplinary skills, including an understanding of the global, entrepreneurial and managerial abilities, and teamwork skills.

The Mechanical Engineering and Mechanics (MEM) Department offers Graduate work is offered on both a full-time and a part-time basis. The majority of courses are scheduled in the late afternoon and evening, so part-time students can take courses together with full-time students. The General (Aptitude) Test of the Graduate Record Examination (GRE) is required for applicants pursuing full-time study.

The department has adopted the Career Integrated Education (CIE) program at the master's level.

Master of Science Program in Mechanical Engineering

The M.S. program has a two-fold mission: to prepare some students for continuation of their graduate studies and research toward a Ph.D. degree and to provide other students with a terminal professional degree to better prepare them for a career in industry.

The M.S. program is structured so that students have the opportunity to specialize in an area of interest while obtaining the broadest education possible.

M.S. candidates are required to take two core-course sequences (two terms each) from any two core areas. Candidates may choose either the thesis or nonthesis option; all M.S. students are strongly recommended to follow the thesis option.

Typical M.S. program		**Credits**
	Two core-course sequences (required)	12.0
	Three mathematics* courses (required)	9.0
	Eight technical electives (including 9 credits for thesis option)	24.0

***Mathematics courses:**

MEM 591	**Applied Engineering Analysis Methods I**	3.0
MEM 592	**Applied Engineering Analysis Methods II**	3.0
MEM 593	**Applied Engineering Analysis Methods III**	3.0

Core Areas

All students take core courses in the department’s areas of specialization as part of a comprehensive and flexible program. Further details can be obtained from the department's Graduate Programs Manual.

The core courses in each area are listed below:

Mechanics Area

Theory of elasticity		**Credits**
MEM 660	**Theory of Elasticity I**	3.0
MEM 661	**Theory of Elasticity II**	3.0

Solid mechanics	**Credits**

MEM 663	**Foundations of Solid Mechanics**	3.0
MEM 664	**Introduction to Plasticity**	3.0

Advanced dynamics		**Credits**
MEM 666	**Advanced Dynamics I**	3.0
MEM 667	**Advanced Dynamics II**	3.0

Systems and Control Area

Robust control systems		**Credits**
MEM 633	**Robust Control Systems I**	3.0
MEM 634	**Robust Control Systems II**	3.0

Non-linear control theory		**Credits**
MEM 636	**Theory of Nonlinear Control I**	3.0
MEM 637	**Theory of Nonlinear Control II**	3.0

Real-time microcomputer control		**Credits**
MEM 639	**Real-Time Microcomputer Control I**	3.0
MEM 640	**Real-Time Microcomputer Control II**	3.0

Thermal and Fluid Sciences Area

Advanced thermodynamics*		**Credits**
MEM 601	**Statistical Thermodynamics I**	3.0
MEM 602	**Statistical Thermodynamics II**	3.0

Heat transfer		**Credits**
MEM 611	**Conduction Heat Transfer**	3.0
MEM 612	**Convection Heat Transfer**	
or		
MEM 613	**Radiation Heat Transfer**	3.0

Fluid mechanics*		**Credits**
MEM 621	**Foundations of Fluid Mechanics**	3.0
MEM 622	**Boundary Layers: Laminar and Turbulent**	3.0

***Consult the Thermal and Fluid Sciences area advisor for other options.**

Doctoral Program in Mechanical Engineering

Outstanding students with a GPA of at least 3.5 in their master's program will be considered for admission to the program leading to the Doctor of Philosophy degree in mechanical engineering.

At least 90 credits are required for the Ph.D. degree. The master's degree is not a prerequisite for the Ph.D., but does count as 45 credits toward the 90-credit requirement. In addition to the 45 credits normally taken for the M.S. degree, students must take at least 18 credits of coursework (exclusive of independent study or thesis credits). The remaining 27 credits consist of a combination of dissertation, independent study, and additional advanced coursework consistent with the approved plan of study. All Ph.D. students are expected to participate in the department's seminar program, course instruction, and other academic activities.

Students who hold a B.S. degree and are currently enrolled in the MEM graduate program can take the Ph.D. candidacy examination after the completion of at least one year of graduate study at Drexel University with a minimum GPA of 3.5 in all engineering and science graduate courses. A student holding an M.S. degree that has not been granted by the MEM Department can take the Ph.D. candidacy examination after completing at least two terms of graduate study at Drexel University with a minimum GPA of 3.5 in all engineering and science graduate courses taken while in the MEM Department.

The Ph.D. candidacy examination consists of two parts, a written part and an oral part. The written part consists of one examination in applied mathematics and one examination in a major area established by the applicant and his or her advisor. Following successful completion of the written examinations, an oral examination is administered. This examination emphasizes, but is not restricted to, the student's major area.

The Ph.D. candidacy examination is given twice each year, at the beginning of the fall and spring terms. Additional details are given in the Mechanical Engineering and Mechanics Graduate Program Manual.

At least one year prior to graduation, candidates must give a presentation to the dissertation committee. The committee must approve the thesis topic and the general method of attack. A final examination consisting of a presentation and defense of the research dissertation is required, before the Ph.D. degree is granted.

Furthermore, Ph.D. students may have to take technical writing courses in fulfillment of their Ph.D. requirements. Foreign Ph.D. students are subject to the same ESL requirements as M.S. students.

Master of Science in Software Engineering

Drexel University's Master of Science in Software Engineering (M.S.S.E.) degree program was created in response to the growing importance of software to the national infrastructure and the rapid rise in demand for professional software engineers.

All students in the M.S.S.E. program take a core curriculum that spans the scope of disciplinary areas relevant to the degree, thereby providing a common foundation for all students in the program. Students also elect an area of concentration, or track — a cohesive, more specialized set of courses that build on the core to support each student's particular career interest. Three tracks are available: information science and technology, computer science, and engineering. Students in all tracks are encouraged to participate in Drexel's Career Integrated Education (CIE) program. The average time to complete the master's degree is two years of full-time study or three years of part-time study.

Master of Science in Software Engineering

Degree Requirements

Degree requirements vary by track. All students take the required six core courses (18 credits).

Core Courses

Core courses cover topics that are essential for the practicing software engineer.

Computer science courses		Credits
CS 575	**Software Design**	3.0
CS 576	**Dependable Software Systems**	3.0
Electrical and computer engineering courses		
ECEC 500	**Fundamentals of Computer Hardware**	3.0
ECEC 600	**Fundamentals of Computer Networks**	3.0
Information science and technology courses		
INFO 627	**Requirements Engineering and Management**	3.0
INFO 638	**Software Project Management**	3.0
	Total credits	18.0

Tracks

Students in each track follow the policies determined by the respective College.

Information Science and Technology Track

Track Coordinator:
Dr. Michael Atwood, 215-895-6273, michael.atwood@ischool.drexel.edu

This track supports students interested in applying software engineering to information systems problems in commercial organizations and other settings. The principal focus is the process by which user and system requirements are converted into cost-effective, maintainable software systems. This is complemented by a concern for defining, creating, understanding, and evaluating the full range of software life-cycle products. The track places particular emphasis on systems values, such as the human-computer interface, front-end user requirements analysis, modeling and validation, and the use of off-the-shelf tools and components to assist in software processes.

Students in the information science and technology track take a total of nine track

courses: four required track courses, three courses selected from the track distribution courses, and two courses selected from the distribution courses or other approved electives. This track requires a total of 45 credits, 18 of which are from the required core. CIE is available for up to six credits. Hence, the CIE option requires students to take six credits more than the non-CIE option.

Required courses		Credits
INFO 608	**Human-Computer Interaction**	3.0
INFO 630	**Evaluation of Information Systems**	3.0
INFO 636	**Software Engineering Process I**	3.0
INFO 637	**Software Engineering Process II**	3.0

Distribution courses		
INFO 503	**Introduction to Information Systems Analysis**	3.0
INFO 605	**Database Management I**	3.0
INFO 614	**Distributed Computing and Networking**	3.0
INFO 620	**Information Systems Analysis and Design**	3.0
INFO 646	**Information Systems Management**	3.0
Elective courses		
INFO 603	**Application Programming for Information Systems**	3.0
INFO 606	**Database Management II**	3.0
INFO 607	**Applied Information and Database Technology**	3.0
INFO 616	**Computer-Supported Cooperative Work**	3.0

Computer Science Track

Track Coordinator: Dr. Spiros Mancoridis, 215-895-6824, spiros@drexel.edu

The computer science track welcomes students who are interested in a variety of technical topics pertaining to the development of software systems such as databases, networks, operating systems, graphics and animation systems, compilers, expert systems, and systems for scientific computing. Students will use languages and apply techniques to specify, design, implement, test, and maintain software systems.

Students in the computer science track take 9 courses in addition to the 6 core courses. Of the 9 courses, 4 courses must be from one of the six concentrations. The other 5 courses are electives that may be fulfilled by any course offered for the M.S.S.E. degree.

Students in their final 3 quarters of study who have a 3.5 GPA or better may take a 9-credit project instead of 3 elective courses. To register for a project, the student must select a project advisor (a member of the CS faculty who is willing to supervise). The project is a large-scale software development effort in which students specify, design, implement, and test a significant software system.

CIE is also available for up to 6 credits. Hence, the CIE option requires students to take 6 credits more than the non-CIE option.

Concentration courses		Credits

Computing systems concentration

CS 543	**Operating Systems**	3.0
CS 643	**Advanced Operating Systems**	3.0
CS 544	**Computer Networks**	3.0
CS 741	**Computer Networks II**	3.0
CS 645	**Cryptography and Network Security**	3.0
CS 675	**Software Reverser Engineering**	3.0

Programming languages concentration

CS 525	**Theory of Computation**	3.0
CS 550	**Programming Languages**	3.0
CS 551	**Compiler Construction I**	3.0
CS 552	**Compiler Construction II**	3.0
CS 680	**Special Topics in Computer Science: Program Generation and Optimization**	3.0

User interface software concentration

CS 536	**Computer Graphics**	3.0
CS 636	**Advanced Computer Graphics**	3.0
CS 530	**Developing User Interfaces**	3.0
CS 630	**Cognitive Systems**	3.0
CS 680	**Special Topics in Computer Science: Game Design and Implementation**	3.0
PSY 612	**Psychology of Human-Computer Interaction Design**	3.0

Artificial intelligence concentration

CS 510	**Artificial Intelligence**	3.0
CS 610	**Advanced Artificial Intelligence**	3.0
CS 612	**Knowledge-Based Agents**	3.0
CS 511	**Robot Building Laboratory**	3.0

Scientific computation concentration

CS 668	**Computer Algebra I**	3.0
CS 669	**Computer Algebra II**	3.0
CS 680	**Special Topics in Computer Science: Methods I**	3.0
CS 680	**Special Topics in Computer Science: Methods II**	3.0
CS 540	**High Performance Computing**	3.0
CS 567	**Applied Symbolic Computing**	3.0
CS 676	**Parallel Programming**	3.0

For additional information on the Computer Science Track, as well as an FAQ, visit the Department of Computer Science's Master of Science in Software Engineering web page.

Engineering Track

Track Coordinator: Dr. Leonid Hrebien, 215-895-6755, lhrebien@ece.drexel.edu

Students in this track pursue techniques to model engineering problems and offer software solutions. The courses in this track emphasize problems facing engineering industries including electrical, mechanical, environmental, chemical, and others. Systems modeling and simulation techniques will be used to solve these problems.

Students in this track take 27 or more credits of track courses in addition to the 18 credits of required core courses. Three computer engineering courses are required; the other courses are from one of five concentrations. A total of 45 approved graduate credits are required for the M.S.S.E., including the 18 credits of core courses. Students opting for the CIE option are required to complete 51 approved credits, including 6 CIE credits.

For more information on curriculum requirements, visit the Department of Electrical and Computer Engineering's Graduate Student Guide.

Courses		Credits
ECEC 511	**Issues in Combinational Circuit Design**	3.0
ECEC 512	**Issues in Sequential Circuit Design**	3.0
ECEC 513	**Design for Testability**	3.0

Chemical engineering concentration		Credits
CHE 554	**Process Systems Engineering**	3.0
CHE 658	**Advanced Process Design**	3.0

Civil and architectural engineering concentration		Credits
CIVE 501	**Model Analysis of Structures**	3.0
CIVE 605	**Advanced Mechanics of Materials**	3.0
CIVE 701	**Structural Analysis I**	3.0
CIVE 702	**Structural Analysis II**	3.0
CIVE 703	**Structural Analysis III**	3.0
CIVE 704	**Behavior and Stability of Structural Members I**	3.0

Electrical and computer engineering concentration		Credits
ECEC 621	**High Performance Computer Architecture**	3.0
ECEC 622	**Parallel Computer Architecture**	3.0
ECEC 623	**Advanced Parallel Computer Architecture**	3.0

NOTE: Any other ECE 600-level or above course may be eligible for credit for the Electrical and Computer Engineering concentration..

Materials engineering concentration		Credits
MATE 605	Computer Simulation of Materials and Processes I	3.0
MATE 606	Computer Simulation of Materials and Processes II	3.0
MATE 670	Materials Processing I	3.0
MATE 671	Materials Processing II	3.0

Mechanical engineering and mechanics concentration		Credits
MEM 534	Discrete Time Control and Estimation I	3.0
MEM 535	Discrete Time Control and Estimation II	3.0
MEM 536	Microcomputer-Based Control of Dynamic Systems I	3.0
MEM 537	Microcomputer-Based Control of Dynamic Systems II	3.0
MEM 574	Introduction to CAM	3.0
MEM 534	Reliability of Mechanical Systems I	3.0
MEM 677	Reliability of Mechanical Systems II	3.0
MEM 678	Reliability of Mechanical Systems III	3.0
MEM 681	Finite Element Methods I	3.0
MEM 682	Finite Element Methods II	3.0
MEM 683	Finite Element Methods III	3.0