The statements set forth in this catalog are for informational purposes only and should not be construed as the basis of a contract between a student and this institution.

While the provisions of this catalog will ordinarily be applied as stated, Georgia Tech reserves the right to change any provision listed in this catalog, including but not limited to academic requirements for graduation, without actual notice to individual students. Every effort will be made to keep students advised of any such changes. Information on changes will be available in the offices of the registrar, the dean of students, and the major schools and colleges. It is especially important that each student note that it is his or her responsibility to be aware of current graduation requirements for a particular degree program.

This institution is in compliance with Title VI of the Civil Rights Act of 1964 and does not discriminate on the basis of race, creed, color, or national origin, and is also in compliance with the provisions of Title IX of the Educational Amendments of 1972 which prohibit discrimination on the basis of sex.

It is the policy of the Institute that sexual harassment as defined in the EEOC Guidelines will not be tolerated among members of the Tech community. Any complaint of sexual harassment should be reported immediately to the appropriate person or persons designated by the vice-president, dean, or director.

The cost of the 1985-86 General Catalog is $41.268 for a total press run of 33,000 copies.

This catalog becomes effective with summer quarter 1985.
When the Georgia Institute of Technology opened its classroom doors in 1888, the concept of a technological education was still new to the South's largely agricultural society. Undaunted by philosophical opposition, the innovative forefathers of Georgia Tech boldly affirmed their belief in the necessity of a quality, technical education and thus opened the door to the future for generations of Tech graduates.

Throughout its first century, the Institute has pursued the goals of quality education, vigorous service, and progressive research, thereby achieving today a position of national prominence. Enrollment has grown from the first class in 1888—129 mechanical engineering students, all but one from Georgia—to almost eleven thousand students from every state and eighty countries. Today, the members of this growing student community work toward undergraduate and graduate degrees in Tech's twenty-one schools and colleges. Men and women who graduate from Tech influence the worlds of architecture, engineering, management, and science; their alumni support, consistently among the most substantial in the nation, ensures that Tech students will continue to receive the high level of technical skill that will prepare them to enter the future confidently and competently.

The Institute's primary goal traditionally has been to provide superlative instruction for capable and intelligent students. The average Scholastic Aptitude Test score for Georgia Tech students is nearly three hundred points higher than the national average, and the Institute enrolls the highest percentage of freshmen National Merit Scholars and National Achievement Scholars among publicly supported institutions in the United States. To meet the needs of these talented individuals, Tech provides a distinguished faculty, approximately 85 percent of whom hold doctoral degrees. Further, the Institute has pioneered and continues to develop such innovative educational programs as the Cooperative Plan, which offers students the opportunity to work in industry and attend school in alternate quarters.
In addition to cultivating responsibility and skill in tomorrow's leaders, Georgia Tech serves the community not only through individual volunteer efforts, but also through extensive research and service projects centered on the campus. The Department of Continuing Education sponsors frequent seminars and workshops for professionals and concerned citizens who seek to expand their knowledge of current issues. All instructional and research units, including the new Advanced Technology Development Center, provide advisory services in engineering, architecture, science, and management as well as on-site development programs for industry and government.

As the South's largest industrial and engineering research agency, with an annual research budget of $95 million, Georgia Tech has contributed extensively to such diverse fields as energy conservation, artificial intelligence, submillimeter waves, digital image processing, remote sensing, chemical kinetic processes, electromagnetic scattering, guidance/seeker technology, electronic countermeasures, and composite fiber structures. Projects conducted at Tech range from solar energy development to complex defense systems research. While scientists in Georgia Tech's seventeen interdisciplinary research centers explore problems such as the effects of radio frequencies on heart pacemakers and the levels of radiation in drinking water, researchers affiliated with the academic schools, laboratories, and departments continue to open new areas of knowledge to investigation. In addition to a fine library, a well-equipped computing center, and the on-campus research centers, the Institute offers its students access to a marine facility at Skidaway Island and the Oak Ridge Nuclear Laboratories in Tennessee.

Celebrating the Centennial of its founding in 1885, the Georgia Institute of Technology eagerly greets the future. Through its dedication to intellectual excellence, the Institute will continue to provide quality education, service, and research for the benefit of its students and the larger community.

**Academic Offerings**

Through the Colleges of Engineering, Sciences and Liberal Studies, Management, and Architecture, Georgia Tech offers programs of study leading to twenty-six undergraduate and thirty graduate degrees. The "Information for Undergraduate Students" and the "Information for Graduate Students" sections of this book contain general information about these degree programs. For more specific information, see the "Curricula and Courses of Instruction" section in this catalog.
Accreditation
The Georgia Institute of Technology is an accredited member of the Southern Association of Colleges and Schools, and many programs within the Institute are specifically accredited by appropriate national certifying agencies. The Accreditation Board for Engineering and Technology (formerly the Engineers' Council for Professional Development) has awarded accreditation to the four-year engineering curricula leading to bachelor's degrees in the following fields: aerospace engineering, ceramic engineering, chemical engineering, civil engineering, electrical engineering, engineering science and mechanics, industrial engineering, mechanical engineering, nuclear engineering, and textile engineering and to the graduate programs leading to master's degrees in the following fields: aerospace engineering, ceramic engineering, civil engineering, electrical engineering, industrial engineering, mechanical engineering, metallurgy, nuclear engineering, environmental engineering, and textile engineering. The American Chemical Society has certified the curriculum leading to the bachelor's degree in chemistry; the National Architecture Accrediting Board has certified the curriculum leading to the Master of Architecture; and the American Assembly of Collegiate Schools of Business has accredited the College of Management.

Special Support Facilities
Library

Tech currently receives over 28,000 serials, including 6,000 periodicals, approximately 75 percent of them in scientific and technical fields. Especially strong is the collection of abstracts, indices, and bibliographies for science and engineering.

The catalog record of the library collection has been converted to Computer Output Microfilm (COM) with reading stations now located on each floor of the library, in selected dormitory areas, in the Student Center, and in each academic department. The Georgia Tech library, in association with the eleven other libraries in the University Center in Georgia Consortium, offers a union catalog of the holdings of all member libraries.

Computing Facilities
The Office of Computing Services provides a wide range of computing services for education, research, and administration. Since 1955 this centralized service facility has operated a variety of systems. In 1983, a Control Data Corporation CYBER 180/855 was installed; in 1984, a second of these systems began operation. These two systems share disk storage and use the NOS operating system. Early in 1985, an IBM 4381 system was installed running MVS under VM. The hardware configuration, a broad variety of programming languages, applications programs, and library subroutines all combine to provide an impressive amount of computer power to both time-sharing, remote batch, and on-site batch users. Time-sharing terminals, CALCOMP and Versatec plotters, and an optical scanner offer additional versatility. Many schools, departments, and administrative offices have their own minicomputers in addition to interactive and remote batch terminals providing access to the central facility.
Georgia Tech Research Institute

The Georgia Tech Research Institute (GTRI), formerly the Engineering Experiment Station, is chartered by the Georgia Legislature as an administrative unit of Georgia Tech. Its missions include serving the community, state, and nation; conducting scientific, engineering, and industrial research; encouraging the development of natural resources of Georgia; aiding industrial and economic development; and participating in the national programs of science, technology, and preparedness. In performing these missions, GTRI is simultaneously making the maximum possible contribution to Georgia Tech's overall research, educational, and service goals.

The GTRI staff represents most of the recognized fields of science and technology, with about six hundred research faculty in the full-time staff of approximately nine hundred persons. An additional 450 faculty, students, and consultants participate on a part-time basis in the research programs.

GTRI is primarily located on the Georgia Tech campus in Atlanta. Activities are also located on an off-campus facility in nearby Cobb County, as well as twelve field offices located throughout the state in Albany, Augusta, Brunswick, Carrollton, Columbus, Douglas, Dublin, Gainesville, Macon, Madison, Rome, and Savannah. In addition, other groups are performing research at the sponsors' locations.

The Georgia Tech Research Institute's activities are coordinated with research conducted by the academic schools and colleges through the vice-president for Research. For additional information, contact the Office of the Director, Georgia Tech Research Institute, Second Floor, Centennial Research Building, Telephone: (404) 894-3411.

Advanced Technology Development Center

The Advanced Technology Development Center (ATDC), formed in 1980, serves as a catalyst for high-technology growth in Georgia. The ATDC assists in the recruitment of new companies to the state, aids early-stage, Georgia-based high-technology companies, and works to build the statewide infrastructure needed to support technology-based industry.

For established companies interested in locating facilities in Georgia, the ATDC offers extensive research information on Georgia's high-technology resources and assistance in gaining access to those resources. For early-stage, high-technology companies and for qualified research and development or new product development groups from established firms, the ATDC provides a battery of support services designed to help a new venture get started and succeed. These services include, when appropriate, business planning and management assistance, access to Georgia Tech facilities and services (such as the Computing Center, Library, and Machine Shop), contacts with the Atlanta business community, aid with marketing of products, introductions to possible sources of financing, and attractive on-campus office space. For qualified companies, the ATDC operates an 83,000-square-foot Technology Business Center on the northern edge of campus. This building offers, in addition to attractive office space, high-bay areas suitable for small-scale production and laboratory activities.

Continuing Education

Continuing Education serves as the Institute's primary educational outreach to both the public and private sectors. This department is the Institute's designated unit for non-credit instruction, provided through workshops, conferences, seminars, and video courses.

The Department uses the Institute's resources in the areas of teaching and research to furnish local, state, regional, national, and international communities with updated information on new ideas, issues, technologies, and developments. The Department of Continuing Education cooperates closely with business, industry, trade associations, and professional organizations in planning and presenting these special educational programs. Programs are conducted on the Georgia Tech campus, at public meeting facilities, hotels, or at company sites. Length of the programs varies from one to ten days.

The Department also delivers graduate level courses and degree programs off-campus through the video-based instructional system.

Industrial Education

The Industrial Education department provides in-plant or on-site training activities to business and industry; develops specialized programs in any technology or field; offers seminars, conferences, workshops, and other activities to satisfy client needs; and conducts programs in safety, productivity improvement, instructing techniques, supervision, statistical control, and a multitude of additional subject areas. In cooperation with the Georgia Department of Education, it develops and conducts specialized training activities for Georgia's textile industry. The department can address most of the training and educational needs of industries and businesses in Georgia.

Oak Ridge Associated Universities

Georgia Tech is one of the sponsors of Oak Ridge Associated Universities (ORAU), a non-profit education and research management corporation of fifty colleges and universities. Concentrating on energy, health, and the environment, ORAU conducts programs of research, education, information, and human resource development for a variety of government and private organizations. ORAU's competitive research programs enable undergraduates, graduate students, and faculty members to work on problems at the research facilities of the United States Department of Energy. Participants are selected by ORAU in cooperation with the staff of each facility.

For more information, contact Dr. Walter O. Carlson, associate vice-president for Graduate Study and Research and Georgia Tech ORAU representative.
Skidaway Institute of Oceanography
Located on Skidaway Island near Savannah, the Skidaway Institute provides a complex of coastal- and marine-related educational and research opportunities. Members of the Tech faculty and their students can either participate in established research activities or initiate research compatible with the facility's purpose.

The Institute maintains small boats, a 40-foot research vessel for near-shore work, and the R/V Blue Fin, a 72-foot vessel for research at distances up to 100 miles offshore. Areas of research expertise at the Institute include chemical oceanography, physical oceanography, biological oceanography, and marine geology.

Interdisciplinary Programs
The Office of Interdisciplinary Programs, established in October of 1973, coordinates interdisciplinary research centers at Georgia Tech. The office currently provides administrative coordination for seventeen units—the Center for Architectural Conservation, the Bioengineering Center, the Research Center for Biotechnology, the Computational Mechanics Center, the Environmental Resources Center, the Fracture and Fatigue Research Lab, the Georgia Mining and Mineral Resources Institute, the Georgia Productivity Center, the Georgia Tech Microelectronics Research Center, the Health Systems Research Center, the Materials Handling Research Center, the Nuclear Research Center, the Center for Radiological Protection, the Rehabilitation Technology Center, the Communication Research Center, the Center for Excellence in Rotary Wing Aircraft Technology, and the Technology Policy and Assessment Center. While the centers offer no designated degrees, center staff members teach courses in other departments and schools of the Institute, assist in the development of interdisciplinary curricula, conduct various research projects, engage in public service programs, and coordinate appropriate interdisciplinary activities.

The Center for Architectural Conservation focuses on research in the technology of existing buildings to promote, enhance, and assist in the conservation and re-use of the built environment.
The Bioengineering Center emphasizes the application of the knowledge, techniques, and approaches of the physical sciences, engineering, social sciences, and management to the problems of the biological sciences. In addition to developing interdisciplinary study and research opportunities for qualified students at Georgia Tech, the Center conducts cooperative programs in bioengineering education and research with other universities and foundations. Curriculum planning and arrangements are coordinated by the Office of the Dean of Engineering.

The Research Center for Biotechnology coordinates the Institute's educational and research programs that deal with biotechnology, including microbiology, genetic engineering, biochemistry, biophysics, chemical and biochemical engineering, and biomass utilization. This multidisciplinary approach provides students and faculty with extended opportunities for developing the complex procedures required for the biological production of valuable products.

The Computational Mechanics Center is dedicated to the advancement of the science of computational analyses. Major research thrusts include non-linear and dynamic fracture mechanics, failure analysis, advanced stress and durability studies, hot section jet engine technology, fatigue analysis, and advanced computational techniques for manufacturing processes.

The Environmental Resources Center coordinates applications of Tech's expertise in science and technology to address problems of managing environmental resources. It organizes and administers water resources research projects throughout Georgia and disseminates their results.

The Fracture and Fatigue Research Lab encourages interdisciplinary research and educational opportunities at Georgia Tech in the field of fracture and fatigue of materials. The research programs encompass the behavior of a wide range of materials, including metals, ceramics, polymers, and composites. For more information, see page 139 of this catalog.

The Georgia Mining and Mineral Resources Institute provides the specialized training in mineral engineering education and research that is necessary to meet the growing technology needs of modern mineral and fuel industries. The programs are essentially multidisciplinary, involving effective use of the wide range of appropriate expertise and facilities that exist throughout the College of Engineering; a Mineral Engineering Certificate may be gained at the bachelor's, master's, or doctoral level. Since the products of the mineral industry—metals, minerals, and energy—are crucial to the U.S. economy and national security, there is now national recognition of the vital need for accelerated growth development of our mineral engineering technology as domestic ore grade inevitably decreases.

The Georgia Productivity Center encourages productivity improvement in Georgia's industries through the application of research, development, and technology transfer. The Center carries out economic analyses to identify factors that affect productivity and performs research projects in various engineering and science disciplines to solve productivity problems. The research results are made available and are transferred through direct assistance offered by Tech's twelve field offices throughout the state in demonstration projects, short courses, and in-plant seminars. Some of the areas to which technology has been applied to improve productivity include reduction of material wastes, energy conservation, introduction of computers, improved plant layouts and manufacturing processes, equipment modernization, and improved work practices.

The Georgia Tech Microelectronics Research Center provides a mechanism for the formal coordination of campus programs of a microelectronics nature conducted within existing campus organizational units. The Center also provides a focus for the development of specialized facilities used in support of interdisciplinary research activities. Typical research programs encompass thin film deposition and characterization, anisotropic etching, high field-hot electron effects on device modeling, laser annealing, and very large scale integration chip design.

The Health Systems Research Center provides an interdisciplinary and interinstitutional program of health systems research, community outreach, and continuing education. The Center develops, applies, and disseminates new knowledge and techniques in all aspects of improved operational and managerial systems for the delivery of health care to the public. The Center emphasizes systematic planning, engineering design, and scientific management of health care facilities, work methods, and human resources.

The Materials Handling Research Center is an industry/university cooperative research center sponsored by U.S. corporations, Georgia Tech, and the National Science Foundation. In response to the research needs of its member companies, the Center performs interdisciplinary research in such areas as factory automation, robotics, advanced sensors, and warehouse automation/logistics. The member companies participate in establishing the research agenda for the Center; they also receive the benefits of the research in advance of any general dissemination.
The Nuclear Research Center provides facilities for physical, chemical, and medical research involving neutrons and ionizing radiations. In particular, it provides access for multiple-discipline users to a five-megawatt research reactor and extensive radiochemical, radioanalytical, and radiobiological facilities. Ongoing work includes trace element analysis, production of radioisotopes for medical and industrial use, medical applications research, neutron radiography, industrial radiation exposure tests, and personnel training programs for industry. An additional program supports reactor use by colleges and universities throughout the southeastern United States.

The Center for Radiological Protection coordinates research and training in health physics. The associated Environmental Radiation Laboratory provides analytical support for faculty research programs complementary to and supportive of the undergraduate and graduate degree programs in health physics.

The Rehabilitation Technology Center facilitates research on devices and systems that help handicapped or disabled persons by removing functional barriers in the workplace, home, and community environments. Collaborative research relationships have been established with the Atlanta Veterans Administration Medical Center, the Division of Rehabilitation Services (Georgia Department of Human Resources), the Roosevelt Warm Springs Institute, and Emory University.

The Communication Research Center collaborates with specialists in academic fields and with corporate managers in developing their capacities to formulate information in both speech and writing. The Center's basic research in composition and discourse processing enables solutions to practical problems of communication in both business and academic settings—problems in document design, information management, software documentation, and training procedures.

The Center for Excellence in Rotary Wing Aircraft Technology provides a national focal point to stimulate more continuous research in helicopter technology and more comprehensive graduate training for engineers in the field. Georgia Tech was selected by the U.S. Army as one of their three centers for excellence in rotary wing aircraft technology.

The Technology Policy and Assessment Center brings together faculty and student research teams to conduct research on major technology policy issues that face our society. Typical areas of investigation involve analyses of social impact, organizational behavior, institutional responsiveness, and cost-risk-benefit features associated with alternative policies and strategies for the management of scientific and technological developments.

Student Life

The vice-president for Student Affairs and his staff coordinate and administer extracurricular student services and activities. For complete information concerning these organizations, see the Guide to Student Life, available to all students from the Office of Student Affairs.
Community Services
Georgia Tech applies its resources through community services to the needs of the community and provides an outlet for creative individual response to social problems.

Counseling and Career Planning Center
Students encountering almost any difficulty may find help at the Counseling Center. Professional counselors assist in a completely confidential manner with academic, career, and personal difficulties whenever students request their services. The Center also provides information on careers, other colleges, admission to law, business, and graduate schools, and a number of tests for determining interests, abilities, and personality traits.

Fraternities and Sororities
The Fraternity Affairs and Women's Programs offices coordinate and administer the many activities and programs of the thirty-eight social fraternities and sororities on the Tech campus.

Student Publications and Radio
The student publications and radio communications boards oversee the budgeting and operation of the Technique, the official student newspaper; the Blueprint, the student yearbook; and other publications, in addition to the operation of the student FM radio station, WREK.

Women's Programs
Students' services and programs aim toward involving female students in all phases of campus life and providing resources to fulfill the Institute's intention of accepting all qualified female students who apply.

Housing Office
The Housing Office supervises the assignment of rooms for 4,200 single students and for 298 married students. A residence hall program provides counseling services and organized activities for residence hall and family housing residents. For further information, refer to the residence hall and/or family housing brochures available at the Housing Office.
Student Health Center
The Student Health Center is a modern ambulatory care center with facilities for outpatient treatment, x-ray examinations, physical therapy, a medical laboratory, pharmacy, and beds for thirty patients.

The staff consists of six full-time physicians, visiting consultants in psychiatry and radiology, a pharmacist, registered nurses, physician assistants, and laboratory and x-ray technologists. The full-time physicians have training in family practice, internal medicine, surgery, gynecology, sports medicine, pulmonary medicine, and emergency medicine. Physicians and dentists on the consulting staff represent all medical and dental specialties; their services are available on a fee for service basis. Funds for operating the Health Center are derived solely from the student health fee.

Since the facilities of the Student Health Center are limited, supplemental insurance to cover major illnesses, major surgery, specialist consultations, and sophisticated diagnostic procedures should be purchased by all students who are not included in their parents' or spouse's medical insurance plans.

International Students
Over nine hundred international students from eighty countries choose Georgia Tech for their educational advancement. The Office of International Student Services and Programs assists these students in adjusting to Georgia Tech and to life in America. In return, many of the students work with the International Student Adviser to develop programs promoting intracultural understanding.

New Student/Parent Programs (FASET)
The student/parent orientation program informs new students and their parents of academic programs and requirements, in addition to familiarizing them with Tech traditions and the activities and services available on campus.

Minority Educational Development
The Office of Minority Educational Development sponsors a variety of programs to assist minority students in adjusting to Georgia Tech. A rigorous pre-college academic program, Challenge, seeks to acclimate students to the pace of scholastic life, while supplemental orientation programs and tutorial and peer counseling services are available to students once they have enrolled.

Placement Service
The Office of Corporate Relations and Placement is located in the Fred W. Ajax Placement Center on Hemphill Avenue. This office offers the Georgia Tech community a variety of services, including opportunities for full-time employment as well as part-time, temporary, and summer employment. One of the primary objectives of the Office is to assist students in determining career objectives and in attaining employment goals.

The Office of Corporate Relations and Placement maintains a library that includes information on specific employers, governmental services, and special publications related to employment. In addition, the Office keeps local and national salary data, employment patterns of Georgia Tech graduates (employers, types of positions, and work locations), and graduate and professional school information.

Other services of the Office of Corporate Relations and Placement include seminars on the employment process, résumé preparation, effective interviewing techniques, and resume-writing campaigns. In addition, the Office issues a résumé book, as well as maintains an open résumé file for employer review. Annually, over seven hundred employers, representing a substantial number of the Fortune 500 corporations, interact directly with the Office.

The Office also provides assistance to corporate university relations officials in the planning, implementation, and administration of effective corporate-university relations programs, in addition to stimulating and encouraging corporate support through financial grants, fellowships, scholarships, faculty support, and equipment.
**Student Center**
The staff of the Fred B. Wenn Student Center plans and coordinates programs and activities for students, faculty, alumni, and their guests. As the vigorous heart of the campus, the Center has post office, recreational, exhibit, and hobby facilities available to serve the diverse interests of Tech's student and faculty population.

**Student Government**
The Georgia Tech Student Government Association and the Graduate Student Senate enable students to maintain responsible and respected self-government in academic and non-academic affairs.

**Health Information**
Students will receive a Health Information and Physical Examination Form with the notice of their acceptance for enrollment. The prospective student should complete the form and mail it to the director of Health Services well before the date of initial registration. All sections of the Health and Physical Examination Form must be completed; otherwise, registration will be delayed. Students should follow the instructions on the health form explicitly and also fill out the summary sheet on the last page. Tuberculosis screening and immunizations as listed on the health form are required of all students. The Physical Examination Section should be completed by the student's family physician.

It is the responsibility of all students to notify the director of Health Services and the Physical Education Department of any disability or handicap that would make participation in swimming, competitive sports, and aerobic training hazardous to their well-being. Any student requesting special consideration because of mental or physical disability should have his or her physician write an explanatory letter to the director of Health Services giving full details of the disability and any desired limitations on physical activity. This letter must accompany the health information record. If students want to continue allergy shots or treatments that have been started by their physician, they should enclose a detailed signed instruction sheet from their physician.

All students from the United States and all international students from Australia, Canada, Denmark, England, Ireland, Netherlands, New Zealand, Northern Ireland, Norway, and Sweden must have a skin test for tuberculosis. This skin test must be current and will not be accepted if it was done more than six months prior to registration. If the skin test is positive, a negative chest x-ray report signed by a licensed physician and taken no more than six months prior to registration must be enclosed. Skin tests and x-rays are performed at most local health departments in the United States at a minimal cost. If the above procedure is not followed, the student will not be permitted to register.
All international students from areas and countries not mentioned above must have a skin test and/or chest x-ray prior to clearance for registration. This skin test and/or chest x-ray must be taken at the Georgia Tech Health Center prior to the date of registration. The cost of these procedures will be borne by the student. These tests will be performed at the Health Center the week prior to registration for the spring, summer, and fall quarters. For the winter quarter, they will be done during registration. Since these tests may take five to six days, students should report to the Health Center as early as possible so that registration will not be delayed.

If the x-ray is abnormal and suspicious of tuberculosis, the student will be referred for diagnosis and treatment. The student may return to classes when the possibility of disseminating tuberculosis is no longer present.

If the student does not comply with the above, he or she will not be permitted to register for classes.

Completed health forms and inquiries should be mailed to:
Director of Health Services
Georgia Tech Student Health Service
275 Fifth Street, NW
Atlanta, GA 30318

Assistance for the Handicapped
Georgia Tech's committee for handicapped assistance and planning ensures compliance with federal law and works to provide a serviceable environment.

Handicapped persons with access problems to buildings and parking should contact the director of campus safety at 894-4588. If you know of any handicapped persons in need of assistance, please notify the equal opportunity/affirmative action officer, the dean of students, or the director of campus safety.

Georgia Tech currently provides the following services for handicapped students: special orientation; wheelchairs for use on campus; reserved parking spaces; reader services for the visually impaired; assistance in securing the services of interpreters for individuals with hearing impairments; aid in registering for classes; assistance from Safety and Security personnel; special assistance from the Student Health Center; and help in securing housing. Tech also allows some students to waive certain course requirements, such as field trips. Students should discuss this option with their academic adviser.

For more information concerning the handicapped, contact the equal opportunity/affirmative action officer in the Carnegie Building at 894-5054.

Annual Notice of Privacy Rights
This institution observes the Family Educational Rights and Privacy Act of 1974 (FERPA), designed to protect student rights with regard to educational records maintained by the institution. Under this Act, students have the following rights: (1) the right to inspect and review educational records maintained by the institution that pertain to them; (2) the right to challenge the content of records on the ground that they are inaccurate, misleading, or a violation of their privacy or other rights; and (3) the right to control disclosures from their educational records with certain exceptions.

A written policy detailing how Georgia Tech will comply with the provisions of the Act is printed in the Guide to Student Life, available in the Office of Student Affairs. The registrar has the institutional responsibility for interpreting (a) the Family Educational Rights and Privacy Act of 1974, as amended, (b) rules and regulations issued by the Department of Health, Education, and Welfare to enforce this Act, and (c) the written policy of the institution.

Students who believe the institution has violated the written policy and/or the provisions of the Family Educational Rights and Privacy Act should send a written complaint to the registrar, specifying the nature of the possible violation. The registrar shall investigate the complaint and initiate corrective action if it appears the institution is in violation. The registrar shall notify the complainant of the results of the review within a reasonable period of time, not to exceed thirty calendar days. Students also have the right to file complaints with the FERPA Office of the Department of Health, Education, and Welfare, Washington, D.C. 20201 regarding alleged violations of the Act.
Affiliated Organizations

**The Georgia Tech Athletic Association**

This not-for-profit corporation administers intercollegiate sports at Georgia Tech through a board of trustees consisting of seven faculty members, three alumni, and three students, with the president of Tech serving as president of the board. The Association aims to secure cooperation of the faculty and students in athletic affairs, to maintain a high standard of sportsmanship, and to provide facilities that allow students to participate in athletic activities. Through the support of the Athletic Association, Tech promotes intercollegiate playing schedules in football, basketball, cross country, swimming, track, golf, tennis, baseball, gymnastics, wrestling, volleyball, and softball.

**The Georgia Tech Alumni Association**

The Alumni Association is a not-for-profit corporation dedicated to serving Georgia Tech. Some of its objectives are to raise funds for Tech through the annual alumni Roll Call, maintain an up-to-date record of each alumnus, publish *Tech Topics* and the *Georgia Tech Alumni Magazine*, organize and assist local alumni clubs, operate a placement service for alumni, organize special alumni events, furnish a medium through which alumni may aid the president and faculty, assist visiting alumni, and help publicize the achievements of Georgia Tech. The executive director is the central contact for all alumni.

**The Georgia Tech Foundation, Inc.**

The Georgia Tech Foundation, Inc., is a not-for-profit, tax-exempt corporation that receives, administers, and invests virtually all contributions made in support of the academic programs of the Georgia Institute of Technology. The Board of Trustees of the Georgia Tech Foundation, Inc., maintains its support of the Institute through its thirty members, distinguished by their expertise in financial management and investments and by their devotion to the school.

The assets of the Foundation exceed $42 million with an annual unrestricted income of over $3 million. Allocation of these funds is made to meet the most pressing needs of the Institute, particularly for faculty professional development and other funding needed to maintain a strong instructional staff and curriculum; undergraduate and graduate student support, both for needy and exceptionally well-qualified students such as National Merit Scholars; and research support, including equipment.

**The Georgia Tech Research Corporation**

The Georgia Tech Research Corporation is a not-for-profit organization that seeks and administers funds for research activity in all administrative divisions of Georgia Tech. It is the coordinating agency for patent applications and other matters related to the protection and use of technological discoveries made at Georgia Tech.
Atlanta

Georgia Tech is located in Atlanta, recently characterized in the *Places Rated Almanac* as one of the most livable cities in the nation. As the capital city of Georgia, Atlanta is home to over two million residents and many of the nation's most prominent business, financial, and industrial firms. Its geographic location has made it the transportation center of the Southeast, as demonstrated by the success of the Hartsfield International Airport, generally considered the nation's largest and second busiest airport. At 1,050 feet above sea level, the city, famous for treelined streets and beautiful gardens, enjoys a pleasant climate permitting year-round outdoor activities. A moderate cost of living—10 percent below the national average—and one of the best public transportation systems in North America contribute to Atlanta's appeal.

Atlanta is also a vigorous city offering an impressive variety of entertainment ranging from sporting events to symphony and theatrical performances. In response to the city's increasing artistic sophistication, Atlanta provides experimental theatre, diverse musical events, a thriving film industry, and a respected art museum. Each spring, the city sponsors a week-long arts festival in Piedmont Park, two miles from the Georgia Tech campus. The historic Fox Theatre hosts varied cultural and popular performances, including ballet, jazz, opera, country, Broadway musicals, and rock concerts. The Braves, Hawks, and Falcons offer quality professional baseball, basketball, and football action for Atlanta spectators. Nearby lakes and mountains offer water sports, camping, and snow skiing for those who prefer more energetic activities. Also popular are such attractions as Six Flags Over Georgia, the Cyclorama at Grant Park, and Stone Mountain Park.
Academic Calendar 1985-86

Georgia Tech operates on the quarter plan with the fall, winter, and spring quarters normally constituting the academic year. A full summer quarter schedule offers students the opportunity to accelerate their programs by attending four quarters per year. Students may enter a course of study or complete their degree requirements and attend a commencement ceremony in any one of the four quarters.

The Office of the Registrar prepares and distributes an official Institute calendar for each quarter. Dates, filing times, deadlines, and other information contained in the official calendar supersede previously published information, including notices in this catalog. Adherence to the requirements set by the official calendar is the responsibility of the student.

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<td>June 24</td>
<td>Registration</td>
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<td>June 25</td>
<td>Classes begin</td>
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<td>September 2</td>
<td>Final exams begin</td>
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<td>September 6</td>
<td>End of term; Commencement</td>
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<td>September 23-24</td>
<td>Registration</td>
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<tr>
<td>December 9</td>
<td>Final exams begin</td>
</tr>
<tr>
<td>December 14</td>
<td>End of term; Commencement</td>
</tr>
<tr>
<td>December 15</td>
<td>Begin Christmas recess</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Winter Quarter 1986</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>January 3</td>
<td>Registration</td>
</tr>
<tr>
<td>January 6</td>
<td>Classes begin</td>
</tr>
<tr>
<td>March 17</td>
<td>Final exams begin</td>
</tr>
<tr>
<td>March 22</td>
<td>End of term; Commencement</td>
</tr>
<tr>
<td>March 23</td>
<td>Begin spring recess</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spring Quarter 1986</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>March 31</td>
<td>Registration</td>
</tr>
<tr>
<td>April 1</td>
<td>Classes begin</td>
</tr>
<tr>
<td>June 9</td>
<td>Final exams begin</td>
</tr>
<tr>
<td>June 14</td>
<td>End of term; Commencement</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Summer Quarter 1986</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>June 23</td>
<td>Registration</td>
</tr>
<tr>
<td>June 24</td>
<td>Classes begin</td>
</tr>
<tr>
<td>September 1</td>
<td>Final exams begin</td>
</tr>
<tr>
<td>September 5</td>
<td>End of term; Commencement</td>
</tr>
</tbody>
</table>
Degrees
The Georgia Institute of Technology at present offers curricula leading to the following undergraduate degrees:

Bachelor of Aerospace Engineering
Bachelor of Ceramic Engineering
Bachelor of Chemical Engineering
Bachelor of Civil Engineering
Bachelor of Electrical Engineering
Bachelor of Engineering Science and Mechanics
Bachelor of Industrial Engineering
Bachelor of Mechanical Engineering
Bachelor of Nuclear Engineering
Bachelor of Textile Engineering
Bachelor of Science
Bachelor of Science in Applied Biology
Bachelor of Science in Applied Mathematics
Bachelor of Science in Applied Physics
Bachelor of Science in Applied Psychology
Bachelor of Science in Building Construction
Bachelor of Science in Chemistry
Bachelor of Science in Economics
Bachelor of Science in Health Physics
Bachelor of Science in Information and Computer Science
Bachelor of Science in Industrial Design
Bachelor of Science in Management
Bachelor of Science in Management Science
Bachelor of Science in Physics
Bachelor of Science in Textile Chemistry
Bachelor of Science in Textiles

Graduates who have completed their courses through the Cooperative Division receive the degree with the designation “Cooperative Plan.”

Requirements for each degree are listed in “Curricula and Courses of Instruction” under the school responsible for the program. Students should select a degree program as early as possible, preferably with their request for admission, but may postpone the decision until a time as late as the end of the freshman year. Students who have selected a degree program receive academic advice from the appropriate school, undecided students through the offices of the deans of the four colleges.

Special Programs

The Cooperative Plan
Since 1912, Tech has offered two plans of study—the standard four-year plan and a five-year cooperative plan for students who wish to combine practical experience with technical theory.

Approximately 2,100 cooperative students, selected from applicants on the basis of high scholarship, work in over four hundred industries throughout the country while they complete academic degree programs.

The cooperative division offers programs for majors in aerospace, ceramic, chemical, civil, electrical, industrial and systems, mechanical, nuclear, and textile engineering, including textiles and textile chemistry, and in chemistry, engineering science and mechanics, information and computer science, mathematics, physics, and management. The academic curricula are identical to those offered regular four-year students.
The plan's alternating college and industrial quarters divide students into two sections, the first registering in June and the second in September. The co-ops of section one and those of section two alternate between industry and college, exchanging places with each other every three months for four years. At the beginning of the fifth year, the two sections merge and remain at college together until graduation in June, when each cooperative student receives a bachelor's degree, cooperative plan, in the student's particular field.

The cooperative program offers the student practical experience and insight into human relations, as well as financial assistance. The work experience co-op students receive is a valuable asset to young graduates starting out in their chosen professions. Neither college laboratory experience nor employment during vacations can take the place of organized co-op training in industry. The plan provides, to a substantial degree, the experience most companies require of their employees before promoting them to positions of responsibility. Work experience may also assist students undecided about their future plans in determining early in their college careers whether they wish to continue the study of engineering, science, or management as a life profession.

Moreover, daily contact with diverse groups among their fellow employees offers students practical insight into sociology, psychology, economics, and ethics that no textbook can supply. Finally, students receive compensation for their services from the firms that employ them. Although students are not able to earn all of their college expenses, as a rule they can earn more than half.

Students interested in applying for admission to the cooperative plan should write to the Director, Cooperative Division, Georgia Tech, Atlanta, Georgia 30332, for the division's bulletin, which gives such information as fees, living expenses, and wages paid students while at work.

**Multidisciplinary and Certificate Programs**

Multidisciplinary Programs in the College of Engineering and Certificate Programs in the College of Sciences and Liberal Studies offer students in good standing an opportunity to broaden their areas of expertise or acquire skills or information beyond their major degree requirements. Students interested in pursuing these programs should consult with their major school adviser.

For a description of Multidisciplinary and Certificate Programs offered in the College of Engineering, see pages 77-78. For a description of similar programs in the College of Sciences and Liberal Studies, see pages 193-194.

**ROTC**

Georgia Tech offers three entirely voluntary ROTC programs that accept both men and women: Army, Navy, and Air Force.

Students may apply six hours of basic ROTC and nine hours of advanced ROTC as elective credit toward a degree. After earning a bachelor's degree and completing the advanced ROTC courses for any of the three services, a student may receive a commission in either the reserve or regular forces.

Each ROTC unit offers scholarship programs of two, three, and four years. All juniors and seniors selected for the advanced courses receive a substantial monetary allowance each month while enrolled in ROTC.

**Dual Degree Program**

To assist the many high school students seeking an educational experience combining a typical liberal arts program with a technological curriculum, Georgia Tech offers the Dual Degree Program. Under this plan, the student attends a liberal arts college for three years, then comes to Tech for approximately two years. Upon completion of the program, the student receives a bachelor's degree from the liberal arts college and a bachelor's degree from Georgia Tech.

Programs of study at Tech may concentrate in any of the various specialty areas of engineering, science, mathematics, or management. The list of colleges participating in the Dual Degree Program incorporates several units of the University System of Georgia, the Atlanta University Center Colleges, and approximately fifty other colleges and universities throughout the nation, including ten traditionally black colleges and many predominantly women's colleges. Because of their classification as transfer students, Dual Degree Program applicants must meet all requirements for transfer.

**Preprofessional Programs**

Georgia Tech's philosophy with respect to preparation for medical, dental, and law school involves preparing students for entrance into the chosen professional school while simultaneously building the educational background for an alternate career. This approach provides each student with a more individualized program and a broader range of options than traditional programs.

In keeping with this philosophy, there are no majors at Georgia Tech designated as premedicine, predentistry, or prelaw. Students pursuing these programs use the elective hours within any major of their choice to take the additional courses required for entrance to medical, dental, or law schools.

This approach to preprofessional education has two major advantages. First, students who do not enter professional school upon graduation, as expected, are prepared to undertake a rewarding alternate career immediately. Secondly, students who continue into professional school can graduate with backgrounds that uniquely qualify them for desirable careers with special emphases, for example, medical research related to artificial organs or the legal aspects of design and construction.

Most successful applicants to medical and dental schools have a broad education in the humanities and social sciences, with particular competence in the natural sciences. Within those guidelines, no specific undergraduate majors have a clear competitive advantage in assuring admission. Therefore, since students whose academic records demonstrate a high level of ability are most likely to gain admission, the best choice of undergraduate major for an individual student is usually the field in which he or she has the greatest inherent interest.

Bachelor's degree programs chosen by premedical and preclinical students are applied biology, chemistry, physics, and psychology.

Most major schools have preprofessional advisers to assist students in choosing electives to build the appropriate background for their professional interests. Also, the Institute has a chief premedical adviser in the Office of the Vice-president for Academic Affairs. Every premedical, preclinical, and prelaw student should consult early with the preprofessional adviser in his or her major area to plan an appropriate program of elective courses.

**Preparation for Careers in High School Teaching**

Georgia Institute of Technology and Georgia State University participate in a cooperative program designed to produce high school science and mathematics teachers with Georgia Tech's expertise in professional education and Georgia State's expertise in professional education. In this program, Georgia Tech students use elective hours to take the required professional education courses at Georgia State. Thus, they simultaneously satisfy the requirements for a Tech degree and teaching certification at the high school level.

This option is available in applied biology, chemistry, mathematics, physics, and psychology. Students desiring to pursue it should consult the appropriate adviser in their major school for help in structuring a program of electives that includes the required professional education courses. This structuring must be done early in the student's academic program to accommodate all requirements.
Joint Enrollment Program for High School Students

Georgia Tech admits a limited number of gifted students who have completed the eleventh grade with academic credentials comparable to those of scholastically superior freshmen at Tech.

Students admitted in this category may take part or all of their course work at Tech including the subject areas needed to fulfill high school graduation requirements. The student receives high school credit for the Tech courses and actually graduates with his or her high school class. Additionally, all work taken at Georgia Tech counts toward an Institute degree if it is part of a particular curriculum taken by the student at a later date.

To be eligible to participate in this program, the local school system must sign the appropriate agreement with the Georgia Institute of Technology. Students should check with local school officials to determine if their particular system is a participating member. If so, the student should discuss with the high school counselor specific requirements for JEPHS. For further information or assistance, contact the Admissions Office at Georgia Tech.

Special Academic Services

In an effort to assist its students in realizing their full intellectual potential, Georgia Tech sponsors a variety of voluntary programs designed to help the student overcome academic problems.

The mathematics department laboratory, open Monday through Friday afternoons while classes are in session, offers a tutoring service for any Tech student in a freshman-level mathematics course. The English department operates a reading laboratory for students who wish to increase their reading speed and improve their comprehension. Students who fail the Regents' Examination in composition, required for graduation, may take a special course to improve their skills. International students may take courses in language and literature designed to introduce non-native speakers to written and spoken English as well as to American customs, ideas, and literature.

The School of Engineering Science and Mechanics provides assistance via videotapes to students having difficulty with beginning mechanics courses.

The STEP program, coordinated through the Office of the Dean of Engineering, provides help with freshman mathematics and science courses. Students may receive quick answers to telephoned questions on current assignments, attend short personal tutoring sessions, and participate in occasional group coaching in particularly troublesome areas.

Admissions

Both freshman and transfer students may enter Tech in any of the four academic quarters which begin in September, January, March, and June. Freshman student deadlines for submission of the Application for Admission, the fifteen-dollar application fee, and all required credentials are as follows:

<table>
<thead>
<tr>
<th>Quarter</th>
<th>Deadline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summer</td>
<td>February 1</td>
</tr>
<tr>
<td>Fall</td>
<td>February 1</td>
</tr>
<tr>
<td>Winter</td>
<td>October 1</td>
</tr>
<tr>
<td>Spring</td>
<td>January 1</td>
</tr>
</tbody>
</table>

Transfer student deadlines for submission of the Application for Admission, application fee, and all required credentials are as follows:

<table>
<thead>
<tr>
<th>Quarter</th>
<th>Deadline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summer</td>
<td>April 1*</td>
</tr>
<tr>
<td>Fall</td>
<td>June 1*</td>
</tr>
<tr>
<td>Winter</td>
<td>October 1</td>
</tr>
<tr>
<td>Spring</td>
<td>January 1</td>
</tr>
</tbody>
</table>

*February 1 for students seeking financial aid.

The Office of Admissions will consider all applications on file by the stated deadlines provided spaces are available for the particular quarter or academic year for which the student applies. An application submitted after the deadline may receive consideration, but only at the discretion of the Institute.

Transfer students should plan their transfer so as to allow ample time for their previous school to send transcripts to Georgia Tech. If Tech does not receive official final transcripts prior to the last day of registration, the Office of Admissions will not allow the student seeking transfer to complete registration.

The Guide to Undergraduate Admissions, designed to assist applicants until their enrollment at Tech, details policies and procedures concerning areas such as admissions requirements, acceptance notification, housing application, financial aid, cooperative plan, joint enrollment, dual degree program, and early admissions. Applicants may obtain this publication from the Office of Admissions.

For any information regarding admission to Georgia Tech, write to:
Director of Admissions
Georgia Institute of Technology
Atlanta, Georgia 30332

Admission of International Students

International students who wish to enroll at Georgia Tech should write to the Office of Admissions for a special information packet describing application procedures and other basic information for applicants from foreign countries. Under most circumstances, international students may enter only in fall quarter.

Advanced Placement and Honors Program

Superior students entering Georgia Tech may receive college credit for courses completed in high school if their scores on the college board Advanced Placement examinations indicate a satisfactory knowledge of college course work. The Department of English and the Schools of Applied Biology, Chemistry, Mathematics, Physics, and Social Sciences participate in the voluntary program by offering both advanced placement and course credit. Minimum AP scores of three in mathematics or history, four in English, chemistry, or physics, and five in biology are necessary for consideration in the advanced placement program.

Advanced placement in chemistry is also possible on the basis of high scores on the college board Achievement Tests. Without sufficiently high scores on the SAT verbal and the English Achievement Test, students may take an essay test administered by the Department of English. Students who pass the test receive credit for English 1001-2 upon successful completion of a Department literature course with a grade of "B" or above.

Under certain conditions, the Department of Modern Languages grants up to twelve hours of credit for high school language study. For more information, see page 239 in this catalog.

Veterans Program

Because the Veterans Administration must receive certification of enrollment before issuing benefit payments, any student planning to enroll under any of the VA programs should initiate the certification procedure through the Georgia Tech financial aid office as early as possible, preferably thirty days before entering the Institute. Veterans should bring with them to the office such documents as proof of discharge (DD-214) or, if previously certified, their VA claim number. Failure to request certification thirty days before registration will result in a four- to six-week delay in the receipt of the first benefit check. For further information about the certification procedure, contact the Office of Financial Aid located on the ground floor of the Administration Building on the Georgia Tech campus.

Veterns must apply to Georgia Tech through the usual admissions procedure. Eligibility for VA benefits does not guarantee acceptance to the institution, nor does acceptance to Tech signify eligibility. The institution serves only as a source of certification and information to the Veterans Administration; the student must carry out all financial transactions with the Veterans Administration directly.

In general, most veterans who served on active duty for more than 180 days, any part of which occurred after January 31, 1955, and before January 1, 1977, are eligible for support to attend college.
Academic Regulations
The "Rules and Regulations" section of this catalog contains detailed information regarding the academic regulations of the Institute. Students who have questions concerning these regulations should consult either the general office of their major school or the Office of the Registrar, Room 104, Administration Building.

Grading System
For detailed information about the Georgia Tech grading system, see "Rules and Regulations," Section IV, in this catalog.

Graduate Course Option
Students who complete both the bachelor's and master's in the same discipline at Georgia Tech may with the approval of their major school use up to nine credit hours of graduate-level course work (as approved by the major school) in the major discipline for both degrees. In order to qualify for this option, the student must complete the undergraduate degree with a cumulative grade point average of 3.3 or higher and complete the master's degree within a two-year period from the award date of the bachelor's degree. Aerospace Engineering, Civil Engineering, Electrical Engineering, Engineering Science and Mechanics, Industrial and Systems Engineering, Mathematics, and Mechanical Engineering are the only schools currently participating in this program.

Institute Rules for the Pass/Fail System
At the option of the major school, a student may receive up to a maximum of twelve hours credit toward a bachelor's degree or six hours credit toward a graduate degree for courses taken under the pass/fail system with a grade of "pass." Such courses apply toward the degree requirements only if the major school has approved the course, either for all majors or for the individual student. The department or school offering a course determines the criteria for a passing grade and may restrict the pass/fail enrollment in any course it offers. The rules for withdrawal from graded courses apply to pass/fail courses as well.

Professors will record only a grade of "pass" or "fail" for any student so designated on the official class roll; students may not change their designation from credit to pass/fail or from pass/fail to credit after the last day to make schedule changes. Neither the professor nor the registrar may change a pass/fail grade to a letter grade, nor may the registrar include courses taken pass/fail in the calculation of grade point averages.

Under certain circumstances, a change in degree requirements may affect a department's position on a course previously approved for degree credit under the pass/fail system. In such cases, the student's major school will decide if a course completed with a grade of "pass" before the change will fulfill the amended requirements.

Only students who complete 180 or more hours toward a degree at Georgia Tech may use the entire maximum of twelve hours credit taken on pass/fail toward a bachelor's degree. For transfer students, second undergraduate degree students, and dual degree students, the number of hours completed at Georgia Tech determines the maximum number of pass/fail hours allowed, according to the following schedule:

<table>
<thead>
<tr>
<th>Quarter</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td>August 1</td>
</tr>
<tr>
<td>Winter</td>
<td>December 1</td>
</tr>
<tr>
<td>Spring</td>
<td>March 1</td>
</tr>
<tr>
<td>Summer</td>
<td>June 1</td>
</tr>
</tbody>
</table>

Former students on "drop" or "review" status should apply at least two months prior to these deadlines in order to ensure sufficient time for the review process. The section "Rules and Regulations" in this catalog contains additional information on readmissions.

Academic Advising
The faculty of each school must provide each student enrolled in that school the opportunity to consult with an informed adviser on the academic program and the selection of courses. Students should seek assistance from their designated faculty advisers regularly during their program of study, particularly when problems occur. Students who do not know the identity of their adviser should consult with the school director. Students undecided about their majors should seek advice from staff members in the office of the appropriate college dean.

Second Undergraduate Degrees
To be a candidate for a second undergraduate degree, a student must obtain the recommendation of the faculty through the director of the school concerned and the approval of the undergraduate Curriculum Committee. This is accomplished by submitting the proposed program of study prior to beginning course work. Should course work be taken prior to receiving the school recommendation and committee approval, the course work completed may have to be used, as applicable, towards the first degree only. See Student Rules and Regulations, Section XIII D for additional information.

Transfer Credit
The basic policy regarding the acceptance of courses by transfer is to allow credit for courses completed with satisfactory grades (C or better) in other accredited colleges, provided the courses correspond in time and content to courses offered at the Georgia Institute of Technology. Tech will not accept credit (except by examination) for courses successfully completed at another institution but previously failed at Tech. The student must request and file an official transcript of transfer courses before the Institute can award credit.

Enrolled students at Georgia Tech must receive prior approval from the student's
remedial English along with other credit course work. If a student fails in the first attempt, he or she must repeat the test.

**ROTC Credit**

Students may apply a maximum of six quarter hours in basic ROTC courses and nine quarter hours in advanced ROTC courses toward meeting the requirements for any degree. For further information, see individual curricula for the Schools.

**Physical Education**

All students attending Georgia Tech must satisfactorily complete physical education requirements during their freshman year. Individual schools may allow a minimum of four hours of 1000- and 2000-level physical education courses and may allow as many as six hours of 1000- and 2000-level courses to be counted toward degree requirements. Students should check the curricula of their individual schools in order to determine the number of hours and/or specific courses that they may apply toward the degree. PE 3100 may be used to satisfy four hours of free electives or technical electives if approved by the major school.

The health information record will determine any medical exemptions from physical education courses. The Department of Physical Education and Recreation will accept certificates of disability from personal physicians only after the Student Health Service has endorsed the documents.

For a complete description of the physical education requirements at Georgia Tech, refer to the Department of Physical Education and Recreation listed under the College of Sciences and Liberal Studies in the "Curricula and Courses of Instruction" section of this catalog.

**Constitution and History Examinations**

The Georgia law as amended March 4, 1953, requires that before receiving an undergraduate degree all students pass examinations or comparable courses in United States and Georgia history as well as United States and Georgia Constitution. Courses that fulfill the United States and Georgia Constitution requirements are POL 1251 or POL 3200. Courses that fulfill the United States and Georgia history examination requirement are HIST 1001 or HIST 1002.

**Regents’ Testing Program**

To establish eligibility for an undergraduate degree, every student in the University System of Georgia must pass the Regents’ Test, an examination designed to measure proficiency in reading and English composition. Students are invited to take this examination when they have earned ten hours of course credit. Any student accumulating thirty hours course credit toward a degree without passing the Regents’ Test must schedule

All curricula leading to an undergraduate degree must include at least thirty-six hours of humanities and social sciences according to the following distribution:

At least eighteen hours of humanities (including at least three hours of literature) selected from the following subjects:

**English:**


**Modern Languages:**

- French, Spanish, Russian, German 1001, 1002, 1003.
- French Languages: 1001, 1002, 1003, 1011, 1012, 1013, 1021, 1022, 1023, 1032, 1033.
- German: 3001, 3002, 3003, 3004, 3031, 3032, 3033, 3041, 3042, 3043, 3051, 3760, 4001, 4002, 4003, 4021, 4022, 4023, 4051, 4052, 4053.
- Russian: 3001, 3002, 3003, 3761, 4901.
- Spanish: 3001, 3002, 3003, 3006, 3011, 4021, 4022, 4023, 4024, 4025, 4026, 4031, 4032.
- French: 2021, 2022, 2023, 3001, 3002, 3003, 3004-5-6, 3007-8-9, 4001, 4002, 4003.

**Studies Abroad:**

4091.

**Music:**

2201, 2202, 2203, 3201, 3202, 3203, 3400.

**Architecture:**

1201, 1202, 1203, 3201, 3202, 3203, 3204, 3205, 4204, 4205, 4206, 4207, 4208, 4209, 4247, 4248, 4249.

**Industrial Design:**

1263.
Financial Information

<table>
<thead>
<tr>
<th>Costs</th>
<th>Resident of Georgia</th>
<th>Nonresident of Georgia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quarterly Fees</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Matriculation</td>
<td>$424</td>
<td>$424</td>
</tr>
<tr>
<td>Nonresidence</td>
<td>$0</td>
<td>$1,035</td>
</tr>
<tr>
<td>Transportation</td>
<td>$9</td>
<td>$9</td>
</tr>
<tr>
<td>Student Activity</td>
<td>$30</td>
<td>$30</td>
</tr>
<tr>
<td>Health Service</td>
<td>$41</td>
<td>$41</td>
</tr>
<tr>
<td>Athletic</td>
<td>$25</td>
<td>$25</td>
</tr>
<tr>
<td>Total</td>
<td>$529</td>
<td>$1,564</td>
</tr>
<tr>
<td>Books and Supplies</td>
<td>$125</td>
<td>$125</td>
</tr>
<tr>
<td>Room and Board</td>
<td>$1,010</td>
<td>$1,010</td>
</tr>
<tr>
<td>Personal Expenses</td>
<td>$225</td>
<td>$225</td>
</tr>
<tr>
<td>(clothing, laundry, recreation, etc.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Per Quarter</td>
<td>$1,889</td>
<td>$2,924</td>
</tr>
<tr>
<td>Total Per Year (3 quarters)</td>
<td>$5,667</td>
<td>$8,772</td>
</tr>
<tr>
<td>Total Per Year (2 quarters)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>for co-op students in school 2 quarters instead of 3</td>
<td>$3,778</td>
<td>$5,848</td>
</tr>
<tr>
<td>Additional Freshman Expenses</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(pocket calculator, drawing supplies—in addition to quarterly costs)</td>
<td>$150</td>
<td>$150</td>
</tr>
<tr>
<td>Total Per Year (freshmen only)</td>
<td>$5,817</td>
<td>$8,922</td>
</tr>
</tbody>
</table>

A non-refundable fee of $15 must accompany all applications for admission to the Georgia Institute of Technology. Upon registration, part-time students (those carrying less than twelve credit hours per quarter) who are legal residents of Georgia pay $36 per credit hour and a transportation fee of $9. Non-resident part-time students pay $124 per credit hour ($36 matriculation and $88 tuition) and a transportation fee of $9.

All students scheduling six hours or more must pay the student activity fee of $30, the athletic fee of $25, and the health service fee of $41.

Since changes in fees may occur without notice, the student must refer to information provided on registration day by the Office of the Vice-president for Business and Finance for official amounts on fees and other institutional charges for each individual quarter.

Obligations of Students
An individual is officially enrolled at Georgia Tech upon payment of all applicable matriculation, tuition, transportation, student activity, athletic, and student health fees for the current quarter. Upon enrolling, every student is obligated to remit, return, or submit all other financial obligations that may become due, as well as property or records of the Institute, within the time prescribed by the Institute. Failure to fulfill any such obligation will result in denial of registration privileges for subsequent quarter(s). Such denial of registration privileges is in addition to and apart from any disciplinary measures that may be taken pursuant to the Student Conduct Code, "Rules and Regulations."

It is the responsibility of the student to be informed of and to observe all regulations and procedures regarding the payment of fees and the entitlement to refunds. In no case will a regulation be waived or an exception be granted because a student pleads ignorance of the regulation or asserts that he or she was not informed of it by an adviser or other authority. All questions concerning fees and refunds should be directed to the Collections Department only. Verbal misinformation is not grounds for a waiver of a regulation.

All fees are payable by the deadline published in the Schedule of Classes for each academic quarter. Registration is not complete until all fees have been paid. Payment may be made either in cash (at a Teller Window in the Cashiers Office) or by check payable in United States currency and drawn on a financial institution in the United States of America. The Institute reserves the right to determine the acceptability of all checks. All checks not drawn in this manner will be returned to the remitter of the check. Counter checks are not acceptable. If a check given in payment of a student's fees, books, supplies, or residence hall rent is not paid upon presentation to the bank on which it is drawn, an academic hold will be placed on the student's records. A student with an academic hold on his or her record will not be permitted to register for further courses.

Books, supplies, or residence hall rent is not paid upon presentation to the bank on which it is drawn, an academic hold will be placed on the student's records. A student with an academic hold on his or her record will not be permitted to register for further courses. This person may not only be permanently withdrawn from the Institute, but may also face legal prosecution. Any person who has a check returned by the bank for any reason should settle that obligation promptly. Failure to do so may result in the placing of the account for collection by a professional collection agency, with the student incurring the full cost of collection.

All matriculation and other charges are subject to change without notice.

Late Registration Fee
Late registration will incur a penalty fee of not more than $100, at the rate of $50 for the first day after regular registration and an additional $25 for each of the next two days. If a student does not pay all required fees by the end of the first week of the quarter, his or her registration will be canceled.
Laboratory and Breakage Fees
Chemistry Breakage Cards may be purchased at the Cashiers Office. Each card costs $10, and refunds are made for the unused portion during the last two weeks of each quarter.

Duplicate Fee Receipts
A student who has lost his or her fees paid receipt is entitled to receive a duplicate upon written request to the Cashiers Office. A charge of $1 will be made for each duplicate receipt. There is a forty-eight hour processing period for duplicate receipts.

Other Fees
The fees listed here do not include fraternity, club membership, or personal transportation expenses.

Each student petitioning for graduation must pay a graduation fee upon submitting the petition. The charge is currently $25. Students must pay this fee each time they submit a petition for graduation.

Each accepted applicant for admission must pay a graduation fee upon registering and each accepted applicant for graduation must pay a graduation fee upon submitting the fee for the use of Institute property.

Duplicate fee receipts.

Refund of Fees
If a student must withdraw from the Institute, the administration will consider requests for fee refunds only through written application. The student should obtain a refund request from the registrar or the Cashiers Office and submit the form, dated and signed, with a copy of the withdrawal application to the Collections Department, located in the Knowles Building, within one month of the registration date.

<table>
<thead>
<tr>
<th>Withdrawal Effected</th>
<th>Percent Refunded</th>
</tr>
</thead>
<tbody>
<tr>
<td>One week following registration</td>
<td>80%</td>
</tr>
<tr>
<td>Two weeks following registration</td>
<td>60%</td>
</tr>
<tr>
<td>Three weeks following registration</td>
<td>40%</td>
</tr>
<tr>
<td>Four weeks following registration</td>
<td>20%</td>
</tr>
</tbody>
</table>

Students who withdraw on or before the last day to register without penalty are entitled to a 100 percent refund. Students withdrawing during the four-week period beginning with the first day on which the late fee applies are entitled to a refund of a certain percentage of matriculation and tuition fees paid for that quarter as follows.

Refund of Fees

Financial Information

Regents' Policies Governing the Classification of Students for Tuition Purposes
Under the Constitution and laws of Georgia, the Board of Regents of the University System of Georgia was created to govern, control, and manage a system of public institutions providing quality higher education for the benefit of Georgia citizens. The State, in turn, receives substantial benefit from individuals who are attending or who have attended these institutions through their significant contributions to the civic, political, economic, and social advancement of the citizens of the state of Georgia.

Because the overwhelming proportion of financial support for the operation of public institutions of higher education in Georgia comes from the citizens through the payment of taxes, the determination of whether a student is classified as a resident or a nonresident of the state for tuition purposes becomes a significant matter. The tuition paid by in-state students covers only about one-fourth of the total cost of their education in the University System. Therefore, Georgia taxpayers are contributing three-fourths of the necessary funds to provide quality education for the citizens of the state.

The practice followed by state colleges and universities of assessing out-of-state students a higher tuition rate is a rational attempt by states to achieve a partial cost equalization between those who have and those who have not recently contributed to the state's economy, even though no precise way exists to determine the degree to which higher tuition charges equalize the cost of educating in-state and out-of-state students. Courts that have been faced with challenges to residency classification procedures have consistently recognized the right of public institutions of higher education to charge higher rates to out-of-state students and to adopt reasonable criteria for determining the establishment of in-state status.

For the purpose of these regulations, the question to be answered is not primarily whether a student is a "resident" or "non-resident" of Georgia, but rather whether the student meets the criteria to pay University System fees on an "in-state" basis. The term "resident" is confusing because it is susceptible of several meanings as it relates to voter registration, driver's licenses, automobile registration, deeds, contracts, wills, income taxes, and other matters. A student may be a resident of Georgia for some purposes, but not entitled to in-state status for tuition purposes.

The Board of Regents has adopted certain policies governing the classification of students as residents and nonresidents for tuition purposes in keeping with its responsibilities to the citizens of Georgia for an appropriate assessment of fees and to ensure that out-of-state students pay a fair and reasonable share of the cost of their education. The taxpayers of Georgia are thereby assured that they are not assuming the financial burden of educating persons whose presence in the state is not intended to be permanent.

With these considerations in mind, the Board of Regents has adopted the below-listed policies governing the classification of students for fee payment purposes.

1. (a) If a person is eighteen years of age or older, he or she may register as an in-state student only upon a showing that he or she has been domiciled in Georgia for a period of at least twelve months immediately preceding the date of registration.

(b) No emancipated minor or other person eighteen years of age or older shall be deemed to have gained or acquired in-state status for tuition purposes while attending any educational institution in this state, in the absence of a clear demonstration that he or she has in fact established legal residence in this state.

2. If a person is under eighteen years of age, he or she may register as an in-state student only upon a showing that his or her supporting parent or guardian has been a legal resident of Georgia for a period of at least twelve months immediately preceding that date of registration.
3. If a parent or legal guardian of a minor changes his or her legal residence to another state following his or her legal residence in Georgia, the minor may continue to take courses for a period of twelve consecutive months on the payment of in-state tuition. After the expiration of the twelve-month period, the student may continue his or her registration only upon the payment of fees at the out-of-state rate.

4. In the event that a legal resident of Georgia is appointed as Guardian of a nonresident minor, such minor will not be permitted to register as an in-state student until the expiration of one year from the date of court appointment, but only upon a proper showing that such appointment was not made to avoid payment of the out-of-state fees.

5. Aliens shall be classified as nonresident students provided, however, that an alien who is living in this country under an immigration document permitting indefinite or permanent residence shall have the same privilege of qualifying for in-state tuition as a citizen of the United States.

6. Waivers: An institution may waive out-of-state tuition for:

(a) nonresident students who are financially dependent upon a parent, parents, or spouse who has been a legal resident of Georgia for at least twelve consecutive months immediately preceding the date of registration provided, however, that such financial dependence shall have existed for at least twelve consecutive months immediately preceding the date of registration;

(b) international students whose matriculation fee and other required fees are paid by an agency of the federal government, a church, or a civic club located in Georgia which has received specific approval of the Board of Regents, provided the number of such students does not exceed the quota approved by the Board of Regents for the institution concerned;

(c) full-time employees of the University System, their spouses, and their dependent children;

(d) nonresident graduate students who hold teaching or research assistantships requiring at least one-third time service at such institution;

(e) full-time teachers in the public schools of Georgia and their dependent children. Teachers employed full-time on military bases in Georgia shall also qualify for this waiver;

(f) career consular officers and their dependents who are citizens of the foreign nation that their consular office represents and who are stationed and living in Georgia under orders of their respective governments. This waiver shall apply only to those consular officers whose nations operate on the principle of educational reciprocity with the United States;

(g) military personnel and their dependents stationed in Georgia and on active duty unless such military personnel are assigned as students to System institutions for educational purposes.

For further information concerning residency, students should contact the Residency Office, Room 104, Administration Building in writing or by telephone (404/894-4152). The Residency Office must receive an application for classification as a legal resident for fee payment purposes no later than one month prior to the academic registration date for the quarter in which the student seeks to pay fees as a resident of Georgia.

Undergraduate Financial Aid

The primary purpose of financial aid at Georgia Tech is to provide assistance to students who, without such aid, would be unable to attend college. The Financial Aid Office and administers all funds provided to Tech for undergraduate student assistance including awards forwarded to the Institute from outside agencies for the use of designated students. Because Georgia Tech will assist students either by awarding funds or by directing the student to other sources of aid, no student should fail to consider attending Tech because of financial problems. However, the financial aid applicant should realize that the amount of aid granted seldom meets all educational expenses, and financial assistance from the Institute will require supplements from the student, family members, and outside sources.

The primary responsibility for financing an education rests with the student and his or her family. Tech, therefore, awards financial aid according to individual need and college costs. Students may receive assistance through scholarships, grants, loans, employment, or a combination of these programs. Of course, the student should help to defray expenses through summer or part-time jobs at Tech or in the Atlanta area. Georgia Tech's Placement Center attempts to keep an up-to-date listing of employment opportunities and can provide more information for interested students. In addition, the Cooperative Program, which is not formally a financial aid program, allows approximately one-fifth of the undergraduate enrollment in the fields of engineering, science, and management to pay part of their college expenses by earning $6,000 to $8,000 per year. Financial need is not a prerequisite for consideration in the co-op plan. Co-op participants are considered for financial aid based upon the same analysis used for other students. Students desiring more information on the Cooperative Program should contact the director of the Cooperative Division, Georgia Institute of Technology, Atlanta, Georgia 30332.

Students applying for financial aid should file their applications for admission to Georgia Tech by February 1 preceding the fall or summer they expect to enroll. The applicant must receive notice of acceptance no later than March 1 to be eligible for full financial aid consideration.

All entering students, including transfer students, who are interested in scholarships, grants, loans, or work opportunities for any quarter of the academic year beginning in September should submit a Georgia Tech financial aid application before February 15 and a Financial Aid Form to the College Scholarship Service during the month of January. Entering students usually receive financial aid awards by May 1.

For additional information and the Guide to Financial Aid, please contact the Director of Financial Aid, Georgia Institute of Technology, Atlanta, Georgia 30332.

Medals and Prizes

Fraternities, academic schools and departments, professional groups, and community organizations award medals and prizes, such as the Phi Kappa Phi award, and present them at the annual Honors Day exercises or at the term's end.
**General Information**

The faculty of the Georgia Institute of Technology grants advanced degrees in engineering, science, management, architecture, and city planning. The goals for graduate studies and research are to establish an educational environment that will encourage and assist students to develop their capabilities both as professionals and as human beings, to encourage students and faculty to press research vigorously for the discovery and generation of new knowledge, to investigate ways of applying such knowledge innovatively for the benefit of society and mankind, and to foster the development of new tools, objects, and ideas.

Students whose interests and aptitudes lead them beyond the limits of the traditional undergraduate curriculum may broaden their knowledge of a given field or pursue independent inquiry through graduate study. A graduate education is of particular benefit to students interested in careers in research, development, design, or consulting; to those who aspire to formulate and administer policy; and to those who desire to enter the profession of education in the fields of engineering, science, or management.

**Degrees and Programs of Study**

**Master's Programs**

Programs of study and research leading to the Master of Science are offered in the following disciplines:

- Aerospace Engineering
- Applied Biology
- Applied Mathematics
- Applied Physics
- Architecture
- Atmospheric Sciences
- Ceramic Engineering
- Chemical Engineering
- Chemistry
- City Planning
- Civil Engineering
- Electrical Engineering
- Engineering Science and Mechanics
- Environmental Engineering
- Geophysical Sciences
- Health Physics
- Health Systems
- Industrial and Systems Engineering
- Information and Computer Science
- Management
- Mechanical Engineering
- Metallurgy
- Nuclear Engineering
- Operations Research
- Physics
- Psychology
- Textile Engineering and Science

See detailed description of programs and courses under appropriate school designations.

**Doctoral Programs**

Programs of study and research leading to the Doctor of Philosophy are offered in the following disciplines and areas:

- Aerospace Engineering
- Applied Biology
- Architecture
- Atmospheric Sciences
- Ceramic Engineering
- Chemical Engineering
- Chemistry
- Civil Engineering and Environmental Engineering
- Economics
- Electrical Engineering
- Engineering Science and Mechanics
- Geophysical Sciences
- Health Physics
- Industrial and Systems Engineering
- Information and Computer Science
- Management
- Mathematics
- Mechanical Engineering
- Metallurgy
- Nuclear Engineering
- Operations Research
- Physics
- Psychology
- Textile Engineering and Science

Through the cooperation of the bioengineering, biotechnology, environmental resources, and health systems research centers and informal programs based on areas of faculty interest, Tech has developed interdisciplinary programs in a number of areas, for example, atomic collisions, complex systems design, radiological health, solid waste technology, transportation, and surface science technology. The College of Engineering lists additional multidisciplinary programs on page 78 of this catalog.

**Graduate Cooperative Program**

Selected students planning to enroll for graduate study at Georgia Tech have the opportunity to participate in a unique cooperative program leading to advanced degrees in participating schools. Two plans are available. One is designed only for Georgia Tech undergraduates and includes study-work periods that span both undergraduate and graduate levels. Eligibility is based on academic achievement at Georgia Tech. The second plan is for graduate students only. Normally, all accepted applicants for graduate degrees are eligible for the program; however, international students will be considered only under exceptional circumstances.

Degree requirements under this plan are identical to those for all students enrolled at Georgia Tech. The Graduate Cooperative Plan is designed as an enhancement to the educational programs of students working for advanced degrees and offers the benefits of added facilities and opportunities for external stimulation. In addition, students receive compensation for their services from companies that employ them.

Preliminary screening of students occurs at the School or College level. The participating companies select students on the basis of academic credentials and interest areas correlated to company activities. For students planning to participate both at the undergraduate and graduate levels, the program requires at least two work quarters at the undergraduate level and at least two work quarters at the graduate level. For students planning to participate only at the graduate
level, the program requires at least two quarters at work.

Students interested in applying for admission to the graduate cooperative plan should write to the Director, Graduate Cooperative Program, Office of Graduate Studies and Research, Georgia Institute of Technology, Atlanta, Georgia 30332 for additional information.

**The Academic Common Market**
The Institute participates in the Academic Common Market Program managed by the Southern Regional Education Board. By interstate agreement, the market enables Southern states to share academic programs. Residents of the participating states who qualify for admission and gain the approval of their state coordinators may enroll on an in-state tuition basis. Georgia Tech programs include ceramic engineering, geophysical sciences, health systems, and textile engineering.

**Policies and Regulations**
Though final authority rests with the Academic Senate, the Graduate Committee with the approval of the Senate is responsible for establishing academic policy for the graduate program. This committee reserves the right to change requirements for degrees as may be appropriate. Students enrolled at the time such changes appear in the catalog have the privilege of following either the regulations stated in the catalog effective the quarter in which they enrolled or the regulations in the catalog that records the change.

This catalog records the Institute-wide policies and regulations that govern the graduate program. Schools may make additional rules concerning programs and the pursuit of their degrees, but these rules may not contradict Institute policies and regulations.

**Graduate Student Work Loads**
Full-time students must enroll for at least twelve hours. The maximum load for full-time students is twenty-one hours, and the minimum load for part-time students is three hours.

Students supported by assistantships must enroll for twenty-one hours, twelve of which must be on letter grade or pass/fail basis. Teaching assistants and non-thesis research assistants must include audit hours in recognition of teaching (8997) and research (8998) activities, as appropriate. Thesis research assistants may include activity audit hours in addition to thesis research hours (7000 or 9000).

Other students with fellowships, traineeships, tuition waivers, or student visas and those assigned to the Institute by the Armed Forces for the purpose of pursuing a degree are required to be enrolled for at least twelve credit hours, excluding audit.

Further information on student loads is available from the Graduate Office.

**Staff Members**
No staff member beyond the rank of instructor in a school may work for a master's degree in that school.

No new staff member with the rank of assistant professor in a school may work for a doctoral degree in that school.

**Admissions Information**
Interested students may obtain information and the necessary forms for admission from either the appropriate school or the Office of Graduate Studies and Research. The student must submit the application, letters of recommendation, and official transcripts or for other admission purposes, must apply to the Schools of Chemistry, Information and Computer Science (Ph.D. applicants only), and Mathematics must take both the Aptitude and Advanced tests of the GRE. Students applying to the College of Management must have General Management Aptitude Test (GMAT) scores sent directly to the Dean of the College of Management.

For information concerning time and location for these tests, write to Graduate Record Examinations, Educational Testing Service, Box 955, Princeton, NJ 08540. Students in western states should write 1947 Center Street, Berkeley, CA 94704.

To obtain general information on the GMAT, write the Educational Testing Service, Box 966, Princeton, NJ 08540.

On-campus applicants may pick up GRE information from the Graduate Office and GMAT information from the College of Management.

**Types of Standing**
Applicants holding a bachelor's degree from an approved institution will be accorded full graduate standing. Applicants holding a master's degree will be accorded conditional graduate standing.

Students who do not wish to qualify for an advanced degree at Tech, but demonstrate the potential benefits of their participation in advanced study may gain admission as special graduate students. Students who are designated special standing for failure to submit official transcripts or for other administrative reasons may credit not more than twenty-four quarter hours taken on special standing toward a degree.

Graduate students in good standing at other universities may enroll at Tech as transient graduate students by filing an application for admission and verification of good standing status from their own graduate dean. However, work undertaken in this program will not apply toward a Georgia Tech degree.

The undergraduate school, not the graduate school, will register students working toward a second bachelor's degree.

In addition to full, conditional, and special graduate standing, graduate students will be classified by academic standing according to their grade point averages—good standing, warning, probation, or drop. For specific information, see "Rules and Regulations," pages 276-277.

**Readmission**
Students who interrupt the continuity of their graduate programs by not registering for one quarter (summer quarter excepted) must seek readmission by filing with the registrar a completed request for readmission form by August 1, December 1, March 1, and June 1 for fall, winter, spring, and summer quarters, respectively. Request forms are available from the registrar's office.

**Reactivation of Application**
Students admitted to the Tech graduate program who do not enter in the quarter for which they applied and subsequently wish to be considered for a later quarter must reactivate their application for the new quarter. Since the registrar's office keeps files on "never entered" students for one year only, these students will have to supply a whole new set of application materials if they delay more than one year in the reactivation request. To reactivate an application, the student must request reactivation in writing.
To the registrar by August 1, December 1, March 1, or June 1 for the fall, winter, spring, or summer quarters, respectively.

Undergraduate Students
Well-qualified undergraduate students with at least a 2.7 cumulative GPA may schedule graduate courses in their senior year. Interested students must obtain permission from their advisers and from the director of the school offering the course.

Undergraduates may receive credit toward the master's degree only under the following conditions:
1. The student must have been in residence at the Georgia Institute of Technology for at least two quarters before registering for the course for which graduate credit is desired.
2. The student normally must not have applied credit for the course toward an undergraduate degree. Students in schools approved to offer the "Graduate Course Option" (see page 38), may duplicate up to nine hours credit for both graduate and undergraduate degrees.
3. The student may request approval to use up to twelve hours credit taken while enrolled as an undergraduate and not used for the undergraduate degree in the graduate program of study.
4. The student must petition the Graduate Committee of the Academic Senate to request such credit.

Registration
During the week preceding first registration, each new student should consult with the director of the school of specialty to prepare a proposed program. At 8 a.m. on the appropriate registration date, listed on page 30 of this catalog, new graduate students should report to their school to receive instructions regarding registration procedures.

Tech also conducts orientation for new graduate students in the fall quarter just before registration.

TOEFL for International Students
All international students from countries in which English is not the native language must take the Test of English as a Foreign Language (TOEFL). Since the results of this test constitute part of the material reviewed for admission to graduate study at Tech, students should arrange to have the Educational Testing Service send their scores to the registrar's office as early as possible. At present, the minimum score required for graduate admission is 550.

Students who wish to take TOEFL should obtain the TOEFL Bulletin of Information for Candidates, International Edition. Applicants can acquire copies of the Bulletin and the registration form through the offices of the United States Information Service (USIS), American embassies and consulates, and United States educational commissions and foundations in a number of cities outside of the United States. In addition, several private organizations distribute the TOEFL Bulletin. These groups include the Institute of International Education (IIE) in Nairobi, Kenya; Paris, France; and Lima, Peru; the African-American Institute (AAI) in Dar es Salaam, Tanzania and Lagos, Nigeria; the American Mideast Educational and Training Services (AMIDEAST) in Amman, Jordan; Beirut, Lebanon; Tangier, Morocco; and Cairo, Egypt; and the American-Korean Foundation in Seoul, Korea.

Students who cannot obtain a TOEFL Bulletin and registration form locally should write well in advance of application to Test of English as a Foreign Language, Box 899, Princeton, NJ, U.S.A. 08540.

The Master's Degree
Prerequisites
Applicants for the master's program should have received a bachelor's degree from a recognized institution and graduated in the upper half of their class. Students must show evidence of preparation in their chosen field sufficient to ensure profitable graduate study.

TOEFL for International Students
All international students from countries in which English is not the native language must take the Test of English as a Foreign Language (TOEFL). Since the results of this test constitute part of the material reviewed for admission to graduate study at Tech, students should arrange to have the Educational Testing Service send their scores to the registrar's office as early as possible. At present, the minimum score required for graduate admission is 550.

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The Master's Degree
Prerequisites
Applicants for the master's program should have received a bachelor's degree from a recognized institution and graduated in the upper half of their class. Students must show evidence of preparation in their chosen field sufficient to ensure profitable graduate study.

Matriculation Requirements
While students may enroll in the master's degree program upon admission with either full or conditional standing, they must attain full graduate status to graduate with the M.S. degree.

Students enrolled for the master's degree must pursue continuous matriculation if the original requirements for their degree remain unchanged. Unless the student maintains matriculation, the school may re-evaluate the student's credentials and impose additional degree requirements.

To sustain continuous matriculation, the student must officially register for at least one quarter per calendar year following original admission.

Students who have completed all course work and are planning to submit a thesis in partial fulfillment of the requirements for a master's degree should register for research hours consistent with a realistic appraisal of the amount of remaining thesis work and required faculty involvement. Students will not receive thesis guidance during any quarter for which they are not registered.

The Institute has no residency requirements for master's level degrees.

Academic Requirements
The master's degree requires a minimum of forty-five approved credit hours distributed as follows:

<table>
<thead>
<tr>
<th>Component</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research hours</td>
<td>15</td>
</tr>
<tr>
<td>Total credit hours</td>
<td>45</td>
</tr>
</tbody>
</table>

The student must earn a graduate grade average of at least 2.7 and satisfy other requirements of the major school to be certified for a master's degree. To compute the grade point average, the registrar assigns grade points for all course work receiving grades, according to the following scale: 4 points for an A, 3 for a B, 2 for a C, 1 for a D, and 0 for an F. The grade average includes the grades on all courses scheduled by the student after admission to graduate study. Other than thesis hours, the student may take only six hours under "pass/fail" designation (see p. 38).

Undergraduate courses required for graduation in the discipline (designated degree) or discipline-of-origin (undesignated degree) at Georgia Tech may not be applied toward a master's degree.

Students, in conference with their faculty advisers, should prepare a program of study for the master's degree as a guide for planning their academic schedules. In some cases, the student's school may require that the proposed program be submitted to the director of that school for approval.

Admission to Candidacy for the Master's Degree
Admission to graduate standing does not constitute acceptance as a candidate for an advanced degree. To obtain consideration for this privilege, the student must have shown evidence of ability to pursue a program of graduate study and research. A mere accumulation of credits is not sufficient. To apply for candidacy, the student must submit to the registrar, during the quarter preceding the anticipated final quarter of work, the petition for a degree (available from the registrar) with the approved program of study attached. To receive favorable action on this petition, the applicant must ordinarily have met the following requirements.

<table>
<thead>
<tr>
<th>Component</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum course credit hours in major field*</td>
<td>27</td>
</tr>
<tr>
<td>Minimum course credit hours at 6000 to 9000 level</td>
<td>33</td>
</tr>
<tr>
<td>Total credit hours</td>
<td>45</td>
</tr>
</tbody>
</table>

*The term "major field" as used in these regulations indicates a basic field of knowledge rather than a department of specialization.

**Must have approval of school director.
1. The student must show that course requirements for the master's degree will have been satisfactorily completed (see Academic Requirements).

2. The student must have completed, or have scheduled to complete during the quarter, any required noncredit prerequisite work outlined at the time of matriculation.

3. The student must have an overall grade point average of at least 2.7 and satisfy the school requirements.

4. The student must have completed satisfactorily any language requirement imposed.

5. The student must have passed any qualifying or comprehensive examinations required by the major department in which he or she is registered.

6. The student must have filed with the Office of Graduate Studies and Research an approved thesis topic and have made satisfactory progress on the thesis if it is a part of the approved program.

Requirements for Award of the Degree

The graduate committee normally recommends to the Academic Senate the awarding of the master's degree to any candidate who:

1. has an overall grade point average of at least 2.7 and has satisfied the requirements of the major school;

2. receives final acceptance of the thesis from the graduate office and submits three unbound copies;

3. supplies the graduate office with a publishable thesis abstract of up to 300 words, certified for accuracy by the thesis adviser;

4. presents an approved program of study (complete within a period of not more than six consecutive calendar years) to the registrar in accordance with the deadline set forth in the Institute calendar;

5. passes any general examinations, oral or written, required by the major school and;

6. is, at the time, a registered student.

Language Requirement

The student's school may require a reading knowledge of one appropriate language.

Transfer of Credit

The rules relative to and the process for obtaining transfer of credit for graduate-level courses are as follows.

1. Students may receive transfer credit (up to nine hours) for graduate-level courses taken elsewhere in the United States and not used for credit toward another degree. The student must supply a current transcript for this evaluation.

2. Joint enrollment students may receive graduate credit for up to one-third of the hours required for the degree for graduate courses taken at Emory University or Georgia State University provided that (a) Tech does not offer such courses, (b) the advisers and school directors approve the courses in writing in advance, and (c) the student passes the courses with a grade of "C" or better. "Advance approval" is satisfied when the courses appear on the student's proposed program of study.

3. Students may not receive transfer credit from universities outside the United States and Canada; however, international students can obtain credit for courses previously taken but not applied toward another degree by filling out an "Examination for Advanced Standing Authorization Request Form," paying the appropriate fee at the Cashier's Office, and passing the examination for advanced standing. The school or department that normally teaches the equivalent course will administer any necessary examinations.

4. To obtain transfer credit, the student should complete the following procedure: (a) The student must confer with the graduate adviser to ascertain whether the courses to be transferred are a logical part of the student's graduate program. The courses would typically be those appearing on the approved program of study form for the master's program student. A doctoral student normally does not request transfer credit. (b) If the courses are appropriate, the student should deliver to the school that teaches such courses a copy of the current transcript, necessary descriptive materials including catalog descriptions, and textbooks used for evaluation. The faculty of the appropriate school will determine the equivalent Georgia Tech course and the number of credit hours accepted. The faculty member who prepares the transfer credit form should have the school director co-sign it. The school should then send the form directly to the registrar with a copy of the student's Approved Program of Study attached. (c) If the student wishes to transfer more than nine hours, a petition must be submitted to the graduate committee including statements of possible justification for the granting of such a petition, transfer credit forms, and the recommendation of the student's school director.

The Master's Thesis

To complete the requirements for the master's degree, students should submit a master's thesis unless their school determines that additional course work is of more importance in meeting approved objectives.

Students who meet the requirements for the master's degree by completing a combination of course work and thesis must register for a minimum of seventeen hours of graduate credit in thesis. (See section on matriculation requirements.)

A candidate whose program includes a thesis must present a treatise in which the results of an investigation directed by a member of the faculty of the Institute are set forth in clear, articulate form. The purpose of the thesis is to further the educational development by requiring the student to plan, conduct, and report an organized and systematic study of importance.

The Manual for Graduate Theses, available from the graduate office, specifies the requirements for the thesis.

The Doctoral Degree

The degree of Doctor of Philosophy recognizes demonstrated proficiency and high achievement in research. After adequate preparation, the candidate must complete a searching and authoritative investigation of a special area in the chosen field, culminating in a written dissertation covering that investigation. The dissertation must be either an addition to the fundamental knowledge of the field or a new and better interpretation of facts already known. It must demonstrate that the candidate possesses powers of original thought, talent for research, and ability to organize and present findings.

Matriculation Requirements

Ordinarily the graduate school admits to the doctoral program only those students who have graduated in the upper quarter of their class.

The matriculation requirements are identical to those outlined for the master's degree except for the residency requirement. Doctoral students must satisfactorily complete at least three full-time quarters of graduate course work for letter grade credit while in residence at the Georgia Institute of Technology and ordinarily must complete research for the dissertation while in residence. Under special circumstances, however, candidates who have met the residence requirements may receive permission to pursue their research in absentia, provided the director of the appropriate school approves and a faculty member directs the project.

Admission to Candidacy

Doctoral students customarily apply for degree candidacy after completing at least five quarters of course work beyond the B.S. degree.

To qualify for candidacy, students must complete all course requirements including any final examinations, achieve a distinguished scholastic record, and pass the comprehensive examination. In addition, the student must file with the school director and the Office of Graduate Studies a formal statement naming the thesis adviser and delineating the research topic, the purpose of the investigation, and a proposed methodology for its completion.

Upon satisfactory completion of these requirements, with approval of the thesis topic, the graduate school formally admits the applicant to candidacy for the degree.
The comprehensive examination assesses both general knowledge of the degree area and specialized knowledge of the student's chosen research field. Each school is responsible for scheduling comprehensive examinations at least once a year, in the fall or spring, and for informing students of their scope. A guidance committee appointed by the director of the school will advise each student in planning a program of study and preparing for the examination, partly through an initial evaluation of the student's background and interests, partly through periodic consultation to evaluate and aid the student's progress.

Students must complete all degree requirements within five years from the end of the quarter in which they pass the comprehensive examination and must have an overall grade point average of 2.7 in order to graduate. During the quarter preceding the anticipated final quarter of work, the candidate must submit a petition for the degree to the registrar. Petition forms are available in the registrar's office.

Major and Minor Fields of Study

While no fixed course requirements apply for the doctoral degree, the student must include in two or more years of graduate course work both a major and a minor field of study. In addition to an adequate knowledge of the major field of intended research, the student must demonstrate mastery of some other, smaller body of knowledge—the minor field—preferably outside the student's particular school. The purpose of the minor is to encourage a wider interest on the part of the student and to provide a broader basis for the evaluation of the student's capabilities.

The minor will normally consist of at least fifteen quarter hours of work in related courses, chosen by the student in consultation with a guidance committee and approved by the Office of Graduate Studies. Once the student has satisfactorily completed the minor, the school director sends a confirmation, accompanied by course grades, to the graduate office for final approval and recording.

Although the student need not complete the minor as a prerequisite for admission to candidacy, the chosen field must be submitted for approval and the program of study must be completed before clearance for the degree.

Language Requirements

The student's school may require a reading knowledge of one or more foreign languages.

The Dissertation

Prior to the student's admission to candidacy, the candidate will present for the approval of the school director and the Office of Graduate Studies a formal statement naming the student's dissertation adviser and setting forth the topic selected for investigation, the objectives the student hopes to gain, and the steps by which the student proposes to gain them. The dissertation topic must give promise of being either a genuine addition to the fundamental knowledge of the field or a new and better interpretation of facts already known.

The dissertation must meet the criteria published in the "Manual for Graduate Theses," which is available in the Office of Graduate Studies and Research.

Prior to the final submission of the completed dissertation to the graduate office, the student must pay the Institute a fee of thirty-five dollars for microfilming the dissertation through University Microfilms, Inc.

The Doctoral Examination

If the Dissertation Advisory Committee finds the dissertation satisfactory, it schedules the candidate for an oral examination on the subject matter for the thesis and the field in which it lies. An examining committee approved by the Office of Graduate Studies will conduct the examination. The student must register for the quarter in which the final examination occurs and for the quarter of graduation.

If both the dissertation and the examination are satisfactory and the candidate has completed the requirements of residence, languages, and minor field, the Office of Graduate Studies will certify the candidate as qualified to receive the degree of Doctor of Philosophy.

If a candidate should fail to pass the final oral examination, the examining committee may recommend permission for one additional examination. In the case of failure, the registrar does not receive a report of the examination results, but the Office of Graduate Studies keeps a record on file.

Schools may add requirements for the doctorate at their discretion.

Financial Information

Costs

The following schedule of matriculation, tuition, student activity, and other fees is effective for the 1985-86 academic session.

<table>
<thead>
<tr>
<th>Matriculation</th>
<th>Tuition</th>
<th>Transportation</th>
<th>Student Activity</th>
<th>Medical</th>
<th>Athletic</th>
<th>Total Fees Per Quarter</th>
<th>Total Fees Per Academic Year</th>
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</thead>
<tbody>
<tr>
<td>Residents of Georgia</td>
<td>$424</td>
<td>$9</td>
<td>$30</td>
<td>$41</td>
<td>$25</td>
<td>$529</td>
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<td>Nonresidents of Georgia</td>
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<td>$1,035</td>
<td>$9</td>
<td>$30</td>
<td>$41</td>
<td>$25</td>
<td>$1,564</td>
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</table>

Special courses may require an extra fee.

Graduate students carrying a full academic load (twelve credit hours or more per quarter) must pay the full amount of all fees as shown above.

Part-time students who are carrying between six and eleven credit hours per quarter and who are legal residents of Georgia must pay $36 per credit hour in satisfaction of the matriculation fee and $96 for the athletic, student activity, and medical fees. Students carrying less than six credit hours pay only the matriculation fee. All nonresident part-time graduate students will have an additional tuition fee of $88 per credit hour. A student must enroll for a minimum of three hours. All students must pay the $9 transportation fee. Hours for which the student is registered shall be consistent with a realistic appraisal of the amount of work yet to be done on the thesis or dissertation and the amount of faculty involvement required.

Note: Conditions may arise beyond the control of the Georgia Institute of Technology that will cause the rate for tuition and fees to be changed during the next year without notice.

Other Fees

Each student petitioning for graduation must pay a $25 graduation fee upon submitting the petition. Students must pay this fee each time they submit a petition for graduation. A candidate for the doctoral degree must pay a charge of $35 for microfilming the dissertation and depositing it with the University Microfilms Service. The Institute assumes the cost of binding the three library copies of a student's thesis or dissertation.

Students who register after the scheduled date must pay a late registration fee. If a
student has not paid all fees by the end of the first week of the quarter, the Institute will cancel the registration.

Refund of Fees
The Institute has an established set of rules governing the refund of fees to students who must drop out of school (see page 44).

Obligations to Students
An individual is not officially enrolled at Georgia Tech until all transportation, tuition, matriculation, student activity, and medical fees for the current quarter are paid. Once enrolled, every student is obligated to remit, return, or submit all other financial obligations that may become due, as well as property or records of the Institute, within the time prescribed by the Institute. Failure to fulfill any such obligation will result in denial of registration privileges for subsequent quarter(s). Such denial of registration privileges is in addition to and apart from any disciplinary measures which may be taken pursuant to the Student Conduct Code, page 281 (“Student Rules and Regulations”).

Financial Assistance
The Institute offers financial aid from a variety of sources to assist students with the pursuit and completion of their degrees as rapidly as circumstances permit. Students should address inquiries for financial aid to the director of the school in which they plan to study.

President’s Fellowships
Each year the Institute awards fellowships to matriculants with outstanding academic records and high research potential. Applicants for the doctoral degree receive most of these awards. The award consists of a $10,000 stipend and the waiver of all tuition and fees for four quarters. These Fellowships are renewable for two additional years, based on the major school’s evaluation and recommendation.

Graduate Research Assistantships
Students ordinarily receive these awards on a one-third or half-time basis; however, schools, departments, and centers or divisions of the Georgia Tech Research Institute may offer awards of a greater or lesser amount according to their specific needs.

Graduate Teaching Assistantships
Schools and departments ordinarily offer these awards on a one-third or half-time basis, but may choose to give awards of a greater or lesser amount according to their needs.

Federal Fellowships and Traineeships
The Institute participates in a number of fellowships and traineeship programs sponsored by agencies of the federal government. In addition, the following traineeships associated with specific training programs are available: water resources planning and management through the Environmental Resources Center, radiation health specialist training program through the School of Mechanical Engineering’s Nuclear Engineering Program, air quality control through the School of Chemical Engineering, and mineral and mining through the School of Materials Engineering.

Tuition Waivers
Nonresident graduate students who hold assistantships or work for the Institute in a professional capacity on at least a one-third-time basis may register upon payment of resident fees. In addition, school directors may recommend to the graduate office a limited number of academically outstanding nonresident full-time students for tuition waivers. Certain IIE students and full-time students sponsored by a group or agency (such as WSF, AFGRAD, LASPAU) to which Georgia Tech has given an institutional commitment may be given top priority for tuition waivers.

Local Industry Work-Study Programs
Many industries located in and around Atlanta offer opportunities to pursue graduate degrees as an integral part of their employee training programs. In such a plan, the student may work and study on a reduced work week schedule that is compatible with school, student, and company requirements. Additionally, the company may choose to pay academic fees, costs of texts, and a supply allowance.

Veterans Program
Veterans may be eligible to receive educational assistance through the Veterans Administration while enrolled and pursuing an approved program of education or training if they were discharged after January 31, 1955, under conditions other than dishonorable from a continuous period of active duty of 181 days or more. If the period was less than 181 days, a veteran may be eligible if the discharge was for service connected disability. The VA provides educational assistance to children of veterans who died or are permanently and totally disabled as the result of service connected disability incurred or aggravated during active service in the Armed Forces, or children of individuals on active duty who are listed for more than ninety days as missing in action, captured by a hostile force, or forcibly interned by a foreign government or power.

The Financial Aid Office at Georgia Tech serves as the veterans affairs center on campus and provides enrollment certification to the Veterans Administration for eligible students. New students and enrolled students wishing to be recertified should make application to the Financial Aid Office at least six weeks prior to the planned quarter of enrollment if they wish to receive the first benefit check for use in registration. For more information, contact the Financial Aid Office at Georgia Tech.

Sponsored Fellowships
The Institute awards a number of fellowships sponsored by various industrial organizations, foundations, and trust funds for the support of outstanding graduate students. These fellowships assist students in pursuing their studies and research full time. Most of these fellowships are restricted to specific areas of study, and interested students should contact the director of the school in which they plan to study.

Fellowships and loans that are not restricted to specific schools include the following.

Domenica Rea D’Onofrio Fellowship
A fellowship in all schools of instruction—recipient must be from Italy. Stipend of $5,000.

Mary White Staton Fellowship
A fellowship in all schools of instruction—recipient must be from Colombia, South America. Stipend of $2,000.

National Consortium for Graduate Degrees for Minorities in Engineering Fellowship
Candidates for participation in this program are selected from minorities (Black Americans, Puerto Ricans, American Indians, and Chicanos). At the time of application, the student should be enrolled in the junior year of undergraduate study in one of the engineering disciplines. In addition to the graduate stipend, this program provides an opportunity for summer work experience in one of several off-campus research laboratories. An applicant’s record must indicate the ability to pursue graduate studies in engineering. Some students who are presently in their senior year of undergraduate study will be accepted into the program. For further information, write to the College of Engineering, Georgia Institute of Technology, Atlanta, Georgia 30332.

Regents’ Opportunity Scholarship
A scholarship in all schools of instruction—recipients must be economically disadvantaged residents of Georgia. Stipend of $5,000.

United States Steel Foundation Loan Fund
A short-term loan fund designated to assist graduate students in engineering, physics, chemistry, and mathematics. Administered by the Financial Aid Office.
This catalog lists alphabetically by colleges the specific degree requirements and course descriptions for each curriculum and course at both the undergraduate and graduate levels.

Course numbers below 1000 denote remedial courses and may not be used in satisfying degree requirements. Course numbers below 3000 indicate lower division (freshman and sophomore) courses. Those numbered 3000-4999 denote upper division (junior and senior) courses, open to students of the lower and upper divisions with the proper prerequisites and to graduate students on approval of the individual student's major school. Courses designed for graduate students are numbered 6000 and above; the methods of presentation and quality of work expected make them generally unsuited to undergraduate participation. An upper-division undergraduate student who has an overall grade point average of 2.7 or higher may therefore enroll in a graduate-level course only after consultation with and approval of his or her major school and the dean of the graduate division.

Figures entered beside the course number and title of each course signify the number of class hours per week, the number of laboratory hours per week, and the quarter hour credit earned for the completed course, in that order. Thus, the entry 4-3-5 in CHEM 1101 means that the course meets for four lecture hours per week and three hours of laboratory per week, and that the student earns five quarter hours credit upon satisfactorily completing the course.

**Handicapped Accommodation**

In order to provide reasonable accommodation to physically handicapped students who are otherwise qualified, consideration by individual colleges, schools, and departments of instruction may be given to the substitution or modification of certain course requirements—within the limitations imposed by the accreditation criteria for the degree program in which the student is enrolled—and to the extent that such substitutions or modifications of the course or curriculum do not have a net effect of detracting from the quality of the educational experience implied by the course or curriculum designation.

Such substitutions or modifications must be approved by the school director, department head, or college dean, and the Undergraduate Curriculum Committee and/or the Graduate Committee.

**College of Architecture**

College established in 1975, school in 1948, department in 1908


**General Information**

The College of Architecture, established in 1908 as the Department of Architecture, became a school in April 1948 when the Georgia School of Technology became the Georgia Institute of Technology. The School achieved the status of a college on July 1, 1975.

The original four-year curriculum led to the degree Bachelor of Science in Architecture. In 1934, this curriculum expanded to a five-year program awarding the degree Bachelor of Architecture, which was offered as a first professional degree until 1972. The four-year degrees, Bachelor of Science in Building Construction and Bachelor of Science in Industrial Design, were established in 1958 following a period during which the curricula in these disciplines functioned as options under architecture.

In 1952, the College initiated the Master of Architecture and Master of City Planning degrees; a joint degree program with the simultaneous award of both degrees has been in operation since 1969. Two-year joint degree programs between city planning and civil engineering (transportation), city planning and urban design, and city planning and environmental design (landscape architecture) at the University of Georgia are currently available.

The original aim and prime objective of the college is to prepare students for the profession of architecture. The scope of man's concern with the environment is of such breadth in current practice, however, that architects and planners not only must demonstrate strength in the traditional role of building and space design, but also must re-emphasize related interests in the social
mechanical systems, management of construction and field processes, and economic and feasibility programming. Graduates with sciences and psychology, structural and construction and field processes, and economic this end that, over the years, the College of Architecture has embraced as many disciplines in design and planning as possible, not only to educate its students in specialized environmental fields, but also to liberalize and expand the education through their interaction.

Recent changes in the content of all curricula take precedence over the listings in earlier catalogs.

**Undergraduate Programs**

**Architecture**
The undergraduate curriculum in architecture prepares the student through basic professional studies and general education to receive the degree Bachelor of Science (undesignated) at the end of four years. This is not a professional degree in architecture and will not be recognized as such by the National Architectural Accrediting Board and the National Council of Architectural Registration Boards; professional degree accreditation applies only to the degree Master of Architecture, awarded after two years of graduate study.

For architecture majors, averages in architectural design will be checked at the end of each year-group of three courses (ARCH 1001-2-3, etc.). The College will not permit a student to enter a more advanced group until his or her record in the previous group equals 2.0 or better. Also, a grade of "C" or better must be achieved in ARCH 4001, 4002, and 4003 to qualify a student for a B.S. degree. All work executed in the College becomes the property of the College and will be retained or returned at the discretion of the faculty. The faculty also reserves the right to refuse for credit any project executed outside the precincts of the College or otherwise executed without proper coordination with the instructor.

Twelve hours of only free electives taken on pass/fail basis may be applied toward fulfilling requirements for the B.S. degree. Math 1710 does not count toward fulfilling any of the degree requirements.

**Curriculum**

<table>
<thead>
<tr>
<th>Freshman Year Course</th>
<th>1st Q.</th>
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<th>3rd Q.</th>
</tr>
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<tbody>
<tr>
<td>ARCH 1001-2-3 Design Fundamentals</td>
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<tr>
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<td>X-X-1</td>
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<td>Electives</td>
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<td>3-0-3</td>
<td>3-0-3</td>
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**Sophomore Year Course**

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<thead>
<tr>
<th>1st Q.</th>
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<tbody>
<tr>
<td>ARCH 2001-2-3 Architectural Design</td>
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<td>1-12-5</td>
</tr>
<tr>
<td>ARCH 2301-2-3 Building Anatomy</td>
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<tr>
<td>PHYS 2111-2-3 Elementary Physics</td>
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<td>4-0-4</td>
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<tr>
<td>ESM 3701-2 States, Mechanics of Materials</td>
<td>......</td>
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<td>Electives</td>
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<tr>
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**Junior Year Course**

<table>
<thead>
<tr>
<th>1st Q.</th>
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<tbody>
<tr>
<td>ARCH 3001-2-3 Architectural Design</td>
<td>1-12-5</td>
<td>1-12-5</td>
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<tr>
<td>ARCH 3321-2-3 Structures and Materials</td>
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<tr>
<td>ARCH 3401-21-41 Urban Planning, Facilities Planning, Building Economics</td>
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<td>Electives</td>
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**Senior Year Course**

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</thead>
<tbody>
<tr>
<td>ARCH 4001-2-3 Architectural Design</td>
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</tr>
<tr>
<td>Totals</td>
<td>13-12-17</td>
<td>13-12-17</td>
</tr>
</tbody>
</table>

**Senior Year Study Abroad Program**
The College of Architecture Study Abroad Program is designed to give senior students in architecture the opportunity to complete all or part of their senior year in residence in Paris, France. The program offers courses paralleling those in the regular program, as well as specialized opportunities for travel and individual study interests. Students participating in the program are registered in the Ecole des Beaux Arts and live in housing arranged by the Institute. While Georgia Tech faculty conduct the courses, faculty of the Ecole des Beaux Arts also participate periodically with the program.

To provide better preparation for living, studying, and traveling in Europe, students should enroll in French language and culture courses at Georgia Tech prior to the senior year.

**Building Construction**

In tandem with the roles of the architect and engineer, the constructor assumes responsibility for bringing a building or group of buildings into physical reality. The Building Construction program emphasizes habitable construction rather than bridges, dams, or other civil work. Basic degree requirements encompass the areas of techniques, operations, and management from which the student may then expand in directions of individual interest through a series of professional electives.

Primary objectives of the Building Construction program are to provide a set of experiences through which technical and management skills can be obtained, along with a broad educational base in order to equip the student for movement toward leadership roles in the construction industry; to develop an educational mix that includes both practical applications and management areas such as scheduling, cost control, construction management, value engineering, and estimating; to provide a curriculum specifically tailored to those entering the construction industry, which retains positive linkages with architecture and engineering in areas of overlap; and to look to the future, as well as the current "state-of-the-art," challenging current methods where appropriate and seeking superior solutions through innovation.

Twelve hours of only free electives taken on pass/fail basis may be applied toward fulfilling requirements for the B.S.B.C. degree. Math 1710 does not count toward fulfilling any of the degree requirements.
## Curriculum

### Freshman Year

<table>
<thead>
<tr>
<th>Course</th>
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<tr>
<td>ARCH 1201-2-3</td>
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<td>BC 1851</td>
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<td>0-3-1</td>
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<tr>
<td>CHEM 1101-2</td>
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<tr>
<td>GEOS 2100-2</td>
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<td>MATH 1207-8-9</td>
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### Sophomore Year

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### Industrial Design

Industrial design is the professional service of creating and developing concepts and specifications that optimize the function, value, and appearance of products and systems for the mutual benefit of both user and manufacturer. Industrial designers, with their wide range of interests and generalist outlook in an age of specialization, must be part artist, part businessman, and part engineer.

The industrial designer's work touches all of our lives in the form of home furnishings, transportation, appliances, recreational equipment, and a myriad of other consumer and industrial products and services. While giving form to the efforts of industry, the designer is at the same time a consumer advocate, providing the humanizing link between technology and the consumer.

The Georgia Tech program offers a well-rounded course of study with early emphasis on basic design. Projects stress realistic design situations; the program encourages students to develop a diverse background in order to expand individual talents and respond to changing opportunities in the field. Most faculty members are practicing designers with extensive experience in the field.

Grade averages in design courses are checked at the end of each year-group of three courses (ID 2001-2-3, etc.). A student may not enter a more advanced group until his or her record in the previous group equals 2.0 or better. All work executed in the College becomes the property of the College and will be retained or returned at the discretion of the faculty. The faculty also reserves the right to refuse credit for any project executed outside the precincts of the College or otherwise executed without proper coordination with the instructor.

Twelve hours of free electives taken on pass/fail basis may be applied toward fulfilling requirements for the B.S.I.D. degree. Math 1710 does not count toward fulfilling any of the degree requirements.

### Electives

<table>
<thead>
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<td>ID 1263</td>
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Graduate Programs

Architecture

The graduate architecture program leads to the professional Master of Architecture degree, accredited by the National Architectural Accrediting Board. The program aims to be responsive to significant shifts taking place in both the discipline and in the profession. Its major objectives are: to offer thorough knowledge of the significant skills, theories, and methods related to the design and production of architecture and to ensure that there is a direct relationship between stated beliefs and actions; to engage the leading questions of the time in whatever aspect of architecture is chosen; and to allow an individual to construct a program of study unique to his or her ability and desire for understanding.

The program has four areas of study: theory and process including decision analysis, descriptive and inferential statistics, and planning methods, including data analysis, forecasting, planning and policymaking processes, risk analysis, implementation, and history and theory of the profession itself; and planning methods, including data analysis, mainframe and micro-computing, descriptive and inferential statistics, micro-economic analytic techniques, modeling, and planning intelligence and information systems.

There are three different curricula arrangements:

a) The Two-Year Program for those holding a four-year bachelor's degree with a major in architecture.
b) The Extended Degree for those holding degrees in fields other than architecture.
c) The One-Year Program for those holding either a bachelor's degree in architecture from a five-year accredited program or for those holding a master's degree in architecture who wish to do specialized post-graduate study.

The Two-Year Program

The program is structured for persons holding a four-year degree with a major in architecture from a school offering an accredited professional degree in architecture. Students having appropriate concentration in architecture in their undergraduate studies can expect to complete this program in two years. A minimum concentration study program has the following requirements:

- Concentration course credits: 12
- Concentration studio credits: 12
- Thesis credits: 18
- Additional required courses: 12
- Electives: 36
- Total: 90

Extended Degree Program

Students admitted to the extended degree program in architecture follow a special basic program for approximately two years. The program is composed of course work in architectural design, architectural history, planning, mechanics, structures, and building components. In the last two years, these students join graduate students who hold an undergraduate degree in architecture.

The previous course of study is taken in account in developing an individual's program. The program assumes that a student's undergraduate work has included a year of calculus for engineers and a year of physics.

The One-Year Program

Persons holding a first professional degree in architecture (Bachelor of Architecture, Master of Architecture, or equivalent) from an accredited school of architecture usually finish the program during one academic year (fifty credit hours). As with the two-year program, the course work is developed within the major study areas outlined above.

City Planning

The graduate City Planning program educates those students whose ultimate goal is the creation of more livable urban environments. Founded in 1951, it is one of the oldest professional planning programs in the United States, with nearly five hundred alumni. Graduates are employed in both the public and private sectors, at all levels of government, by banks, real estate and development companies, utilities, and private corporations. The program is fully recognized by the American Institute of Certified Planners.

Approximately half of the program consists of required courses, called the core. The core is composed of three substantive streams: urban, regional, and locational development economics and policy; planning theories and processes including decision analysis, forecasting, planning and policymaking processes, risk analysis, implementation, and history and theory of the profession itself; and planning methods, including data analysis, mainframe and micro-computing, descriptive and inferential statistics, micro-economic analytic techniques, modeling, and planning intelligence and information systems.

The core is largely contained within the student's first year; in the second year he or she chooses among several areas of specialization. Examples of these specialties include transportation planning, urban design and physical planning, development planning and real estate, environmental and energy planning, and neighborhood and community development planning.

Two types of degree programs are available for students interested in the fields of urban and regional planning: the two-year professional master of City Planning degree (recognized by the American Institute of...
Certified Planners for membership purposes) and the joint programs described below.

The two-year curriculum requires, for most students, five quarters of course work and a seventeen-credit (one quarter) thesis. Students are allowed to substitute four courses in their concentration for the thesis and write a six-credit thesis option paper. An approved internship is required for those students with no previous planning work experience.

The City Planning program maintains joint degree programs with three other academic units: urban design in architecture at Georgia Tech, transportation in civil engineering at Georgia Tech, and environmental design in landscape architecture at the University of Georgia. A description illustrating the urban design joint degree program follows. A student can structure his or her program so that required courses taken in one program can serve as elective credit in the other; thus allowing the student to receive two master's degrees in less time than the two would take to complete if enrolled separately. In addition to these three joint degree programs, planning maintains communications with the programs in real estate at Georgia State University, where a certificate in real estate can be obtained, and with public administration at the University of Georgia. Programs of study can coordinate offerings in these two areas.

The College offers a joint degree program in urban design as a cooperative effort between the Architecture and City Planning programs. Students completing this program receive both the Master of Architecture and the Master of City Planning degrees. The program requires a minimum of 100 hours (two years) for those who hold the Bachelor of Architecture degree and 134 hours (two and two-thirds years) for those who hold the Bachelor of Science degree in Architecture. Students must be admitted simultaneously to both graduate programs.

**Doctoral Program**

The Doctor of Philosophy is an advanced degree directed towards proficiency in independent scholarly work in Architecture and City Planning. The program includes course work in the nature of philosophy of inquiry, additional specialized work in the area of a doctoral dissertation and in one or more other areas, competence in a foreign language, the satisfactory completion of a comprehensive examination, and an independent research dissertation. For further details of the program, contact the Director of the Doctoral Program, College of Architecture, Georgia Institute of Technology, Atlanta, Georgia 30332.

**Courses of Instruction**

**ARCHITECTURE**


ARCH 2001-2-3. History of Architecture I, II, III 3-0-3 each. A study of man's architectural heritage from the beginning of recorded history to the present day. Open to all freshmen.


ARCH 2001-2-3. Building Anatomy I, II, III 3-0-3 each. Introduction to building frames, components and construction techniques, requirements and design of climate control systems, sound and lighting control.

ARCH 2361-2. Color Theory I, II 1-3-2 each. Lecture and laboratory experiments on the properties of color and its use in design.


ARCH 3001. History of Ancient Architecture 3-0-3. Prerequisites: ARCH 1201-2-3 or consent of the College. Historical survey of the architecture of antiquity from prehistoric times through the second century A.D. Emphasizes the architectural traditions of classical antiquity.

ARCH 3002. History of Medieval Architecture 3-0-3. Prerequisites: ARCH 1201-2-3 or consent of the College. Historical survey of the architecture in Medieval Europe including the Early Christian, Byzantine, Dark Ages, Romanesque, and Gothic eras.


ARCH 3204. History of Baroque and Rococo Architecture 3-0-3. Prerequisites: ARCH 1201-2-3 or consent of the College. Historical survey of European architecture during the seventeenth and eighteenth centuries.

ARCH 3205. The Architect and Society 3-0-3. Prerequisites: ARCH 1201-2-3 or consent of the College. The role of the architect in society from the Classical Greek period to the twentieth century.


Survey and historic background of urban planning in the United States; criteria for design and evaluation of buildings; economics of building development, construction and operation.

ARCH 3811-2. Special Topics—Visual Communications 0-3-1 each. Introductory studio work in drawing and painting, sculpture, and three-dimensional concepts.

ARCH 3815-6. Special Topics—Visual Communications 0-3-2 each. Introductory studio work in drawing and painting, sculpture, and three-dimensional concepts.

ARCH 3911-2. Special Problems—Visual Communications 0-3-1 to 0-15-5. Introductory studio work in: (1) drawing and painting, (2) sculpture and three-dimensional concepts, (3) photography, (4) graphic design and rendering.

ARCH 4001. Architectural Design I 1-12-5. Prerequisite: ARCH 3003. Architectural design synthesizing material presented in previous years.

ARCH 4002-3. Architectural Design II, III 1-12-5 each. Prerequisite: ARCH 4001.
ARCH 4304. Energy Flow in a Systems Context
3-0-3. Prerequisite: consent of the College.

ARCH 4751-2. Psychology of Environmental Design
1, II
3-3-6 each. Prerequisite: consent of the College. Course listing and description found under PSY 4751-2.

ARCH 4811-2. Special Topics—Visual Communications
0-3-1 each.
Intermediate studio work in drawing and painting, sculpture, and three-dimensional concepts.

ARCH 4815-6. Special Topics—Visual Communications
0-6-2 each.
Intermediate studio work in drawing and painting, sculpture, and three-dimensional concepts.

ARCH 4821-2-3. Special Topics in History and Theory
3-0-3 each. Prerequisite: consent of the College. Topics in advanced areas of history and theory of architecture.

ARCH 4851-2-3. Special Topics
3-0-3 each.

ARCH 4911-2-3-4. Special Problems—Visual Communications
0-3-1 to 0-15-6. Prerequisites: ARCH 3911-2-3-4. Intermediate studio work in (1) drawing and painting, (2) sculpture and three-dimensional concepts, (3) photography, (4) graphic design and rendering.

ARCH 4915-6-7-8. Special Problems—Visual Communications
Credit to be arranged. Prerequisite: consent of the College. Self-directed studies in visual communications arts.

ARCH 4941-2-3-4-5. Special Problems
Credit to be arranged.

ARCH 4951-2-3-4. Special Problems
Credit to be arranged.

ARCH 6011-2. Architectural Design Studio I, II
Examination of processes and methods of architectural design within the framework of science and the arts, including a variety of historical and contemporary positions.

ARCH 6121. Architectural Design Methods
3-0-3.
Study of building design principles and methods in architectural design.

ARCH 6211. Architectural Design Theory
3-0-3.
Study of building design principles and methods in architectural design.

ARCH 6212. Urban Design Theory
3-0-3.
Evolution of urban design theory from the Renaissance city to the present, particularly the dialectic of utopian thought and actual historical evidence of city form.

ARCH 6221. Readings in Urban Theory
3-0-3.
Investigations of urban design theory and practice during the 19th and 20th century. Emphasis on formal, scientific, social, and economic interpretations of the city.

ARCH 6222. Readings in Landscape Architecture
3-0-3.
History of the design of the landscape and the garden from Ancient Egypt, Persia, and the Orient to the present.

ARCH 6223. Studies in Landscape Architecture
3-0-3.
History of the design of the landscape and the garden from Ancient Egypt, Persia, and the Orient to the present.

ARCH 6262. Readings in Architectural History
3-0-3.
Presentation and discussion of topics of current interest and specialized scope, utilizing the special resources of the landscape history and current architectural history publications.

ARCH 6263. Housing and Culture
3-0-3.
Anthropological, psychological, and architectural theories of house form and culture.

ARCH 6264. Intentions in Architectural History
3-0-3.
Readings on the meaning of architecture, the nature of architectural history, and the varied interpretations of architecture evidenced in architectural historiography.

ARCH 6341. Energy in Architecture
3-0-3.
An investigation of energy requirements in buildings and the use of interactive computer programs to analyze and minimize energy usage.

ARCH 6342. Building Energy Analysis
3-0-3.
Appropriate techniques, strategies, and methods for predicting and evaluating building energy performance. Lab exercises emphasize the relationship between architectural design decisions and predicted building performance.

ARCH 6351. Advanced Architectural Acoustics
3-0-3.
Design requirements for noise control and acceptable room acoustics. Practical design problems, materials selection, and calculation of sound propagation parameters.

ARCH 6371-2. Computer Programming for Architects
I, II
3-0-3 each. Prerequisite: consent of the College. Development of advanced programming skills emphasizing algorithms of special interest to architects.

ARCH 6401. Landscape Resource Analysis
3-0-3.
Prerequisite: graduate standing. Analysis and design methods for solving large-scale or complex site development problems in both the public and private sectors.

ARCH 6402. Introduction to the Preservation and Conservation of Cultural Resources
3-0-3.
Prerequisite: graduate standing. Preservation considering technical, economic, market, and aesthetic problems of assessing, restoring, and adapting historical buildings for alternative occupancies.

ARCH 6403. Preservation/Conservation Methods
3-0-3.
Contemporary methods and processes of historic preservation considering technical, economic, marketing, and aesthetic problems of assessing, restoring, and adapting historical buildings for alternative occupancies.

ARCH 6406. Urban Topography
3-0-3.
Description and interpretation of the contemporary city as a complex phenomenon of transformations in physical form, architectural and social history, economic and social values.

ARCH 6422. Transportation Architecture
3-0-3.
The transportation termini as a building type and urban institution, including historical development, technological change, economic change, and architectural expression in the city.

ARCH 6441. Housing Economics
3-0-3. Prerequisite: graduate standing. Economics of the housing delivery process in the private sector. Planning, developmental marketing, and management of housing.

ARCH 6442. Construction Cost and Valuation
3-0-3. Prerequisite: graduate standing. Cost and valuation approaches to building construction, project development, and design from an economic valuation viewpoint. Income-producing properties are studied in depth.

ARCH 6444. Building Life Cycle Costing
3-0-3.
The concepts, techniques, and applications of life cycle costing as a basis for evaluating architectural performance and design decisions.

ARCH 6445. Economics of Building Development
3-0-3.
Examination of the architectural implications of the construction industry's financial procedures, practices, and requirements.

ARCH 6446. Urban Development Methods
3-0-3.
Investigations of urban development process and roles of the architect and planner in shaping the contemporary city. Methods of financial analysis, programming, and project packaging.

ARCH 6451. Professional Practice of Architecture
3-0-3. Prerequisite: graduate standing. Principles of architectural office organization and project management, the legal framework of architectural practice and contracts, and the techniques of contract administration.

ARCH 6461. Studies in Environment and Behavior
3-0-3.
An examination of interactions between people and the designed environment, focusing on how various settings affect human safety, satisfaction, productivity, and performance.

ARCH 6462. Interdisciplinary Concepts and Values in Architecture
3-0-3.
Rationalism, empiricism, structuralism, instrumentalism, and other frameworks prevailing in the behavioral and social sciences are assessed with regard to their implications for architectural design.

ARCH 6463. Subcultural Issues in Architecture
3-0-3.
Consideration of ways cultural experience, physical ability, social class, and other issues influence the users' reactions to and use of designed environments.

ARCH 6464. Post Occupancy Evaluation
3-0-3.
Evaluations of users' response to and satisfaction with designed environments are developed using design-oriented research methods and analytic techniques.

ARCH 7000. Thesis
Advanced problems in architectural design. Studio exercises emphasize the experimental development and application of theories and methods to complex problems.

Advanced design problems in the contemporary city formulated on theoretical positions, including considerations of utopian positions, type and topology, historical precedent, civic design, and contextualism.

Experimental application in architectural technology in the area of building physics, material performance, and construction methods.

Exploring new boundaries in the application of behavioral information to architectural design.

ARCH 7201. Readings in Architectural Theory 3-0-3.
Detailed critical analysis of selected works in architectural theory.

ARCH 7202. Architectural Criticism 3-0-3.
An examination of theories of criticism in architecture, historiography, film, and literature and their application to subjects in architecture and urban design.

Morphological analysis of urban physical settlement patterns. Ecological, social, economic, and cultural characteristics as determinants of urban form and structure from prehistory to present.

ARCH 7223. Language of the City 3-0-3.
Critical analysis of contemporary theories in the representation of architecture and the city in literature, graphic arts, and film.

ARCH 7224. Studies of the American Landscape 3-0-3.
A topical study of the man-made American landscape with emphasis on the theme of pastoralism in American culture.

Advanced problems in urban design and development in the city of Atlanta. Integration of urban design theory and methods, economic development, political negotiation, and communication.

A continuation of projects begun in ARCH 7441.

An examination of models that present direct relationships between the physical organization of spaces and patterns of individual or collective behavior.

ARCH 8143-53-63-73-83-93. Special Topics 3-0-3 each.

ARCH 8151-2-4-5-6. Special Topics 1-0-1 through 6-0-6, respectively.

ARCH 8213. Special Topics - Urban Design 3-0-3.

ARCH 8223. Special Topics - History and Theory 3-0-3.

ARCH 8233. Special Topics - Architectural Technology 3-0-3.

ARCH 8243. Special Topics - Architecture and Behavior 3-0-3.

ARCH 8253. Special Topics - Architectural Research 3-0-3.

ARCH 8550-1-2-3-4-5-6. Special Problems Credit to be arranged.

BUILDING CONSTRUCTION
BC 1851. Building Construction Seminar 0-3-1.
Introduction to the construction industry. Sources, properties, and uses of construction materials.

Study and analysis of job planning required, work methods, materials, systems, and equipment employed on light construction projects which include residential and small commercial buildings.

Continuation of BC 2001 with emphasis on medium-sized commercial and industrial projects.

Classification of work and quantity survey techniques. Analysis and determination of costs of construction operations including preparation of bid proposals.

Principles, methods, organizations, and problems related to construction management.

BC 3302. Construction Practice II 3-0-3. Prerequisites: BC 3301, MGT 3260.
Management contracts, bonds, insurance, bid documents, and legal aspects of construction management.

Financial consideration and cash flow requirements for construction projects and organizations.

Methods analysis and human factors in construction project management. Processes by which building facilities are produced and delivered.

Review and examination of major component building systems in use today. Discussion of anticipated future requirements for systems and potential impacts on the construction process.

BC 4441. Land Development 3-0-3.
Fundamentals underlying the economics and political determinants of land use, ecological considerations, and the techniques for implementing the development of land.

BC 4442. Value Engineering in Construction 3-0-3.
Analysis of material, equipment, facilities, procedures, and supplies to achieve lowest possible cost consistent with performance requirements to attain optimum quality in building.

BC 4443. Industrial and Construction Safety 3-0-3.
The 1970 Occupational Safety and Health Act as it applies to the building contractor to provide safe working conditions and to the designer to provide safety in buildings.

BC 4444. Real Estate Investment 3-0-3.
Fundamentals underlying the economic structure of physical development. A study of the matrix of development processes and investment decisions.

BC 4446. Construction Management 3-0-3.
Management of construction processes including the pre-design, design, and construction phases. Services and methods used by architects, contractors, and independent consultants performing construction management.

BC 4951-2-3. Special Problems in Construction Credit to be arranged. Prerequisites: senior standing and special permission.
Special problems in construction methods, schedules, or management for students in advanced architectural design or construction projects. Research in innovative methods, processes, systems of construction.

CITY PLANNING
CP 1100. Introduction to City Planning 3-0-3. Fall quarter.
An orientation to urban and regional planning including organization, functions, techniques, and methods of implementation.

CP 4801-02-03-04-05-06-07-08-09-10. Special Topics 3-0-3 each.

CP 6010. Land Use Planning 3-0-3.
Factors determining land use, location, and interrelationships of various land uses, land use studies and plan preparation, implementation of land use policies and plans.

CP 6020. Planning Legislation and Regulation 3-0-3.
Theory and use of eminent domain, taxing and police powers, enabling acts, charters, official maps, codes, restrictive covenants, controlled highway access legislation.

CP 6030. Planning Legislation and Regulation 3-0-3.
An intensive study of zoning—its history, principles, uses, and limitations through review of significant court cases and subdivision regulations.

CP 6050. Housing and Urban Renewal 3-0-3.
Urban renewal problems, programs and techniques including legislation, identification of renewal areas, planning, administration, relocation, financing, and real estate problems.

Planned change in context of public works planning and development, plan implementation, population analysis, public participation, conflict value assessment, and information transfer.

CP 6150. Environmental Aspects of City and Regional Planning II 3-0-3.
Field analysis of noise, air, water, and spatial pollution. Students identify, evaluate, and apply city planning solutions to environmental problems.

CP 6160. Environmental Noise Management 3-0-3.
Management and administration of environmental or community-generated noise, analysis of noise impact, noise management, instrumentation, rating methods. Evaluation of laws and management programs.

CP 6180. Urban Spatial Management 3-0-3. Prerequisite: graduate standing or consent of instructor.
Examines city as three-dimensional resource: aerial, ground, subterranean land uses. City planning methods of multiple use, joint use, and adaptive use are discussed.

CP 6220. Design of Sites and Cities 1-0-3. Prerequisite: graduate standing or consent of instructor.
Explores methods of analyzing large-scale landscapes for complex development programs in public and private sectors. Case studies are used to illustrate application of such methods.
CP 6320. Problems in Community Planning I 1-12-3. Prerequisite: graduate standing or consent of instructor.
Preparation of a series of sectoral plans for an existing urban area. Site visits and discussion with planners, citizens, and politicians of issues and plans.

CP 6240. Problems in Community Planning II 1-12-6. Prerequisite: CP 6320 or consent of department.
An in-depth study of a specific urban or regional planning problem prepared for a client agency or citizens' organization.

CP 6270. Economic Analysis of Urban Areas 3-0-3.
An examination of methods and techniques for analyzing the economic base of urban communities, special emphasis on problems of handling population, employment, and income data.

CP 6280. State and Local Finance 3-0-3.
Program design, analysis, operation, evaluation, expenditure and revenue estimates, capital, and operating budgets.

CP 6300. Theory and History of Urban Planning 3-0-3. Prerequisite: graduate standing or consent of instructor.
Introduction to history of planning profession; examination of theories of planning, comprehensiveness, citizen participation, professionalism, public interest, and planning roles and practices.

CP 6320. Urban Fiscal and Budget Systems 3-0-3. Prerequisite: graduate standing or consent of instructor.
Survey of public sector fiscal planning issues emphasis on current and capital budgeting, debt financing, public expenditures and revenues, and analysis techniques.

CP 6330. Planning in the Intergovernmental System 3-0-3. Prerequisite: graduate standing or consent of instructor.
The nature of the American intergovernmental system, describes how it is managed today and conveys techniques for implementing plans within that system.

CP 6375. Planning with People 3-0-3.
Problems of planning with selected subgroups in urban societies; minorities, the aged, residents of the inner city, suburbanites. Impact of environment on individuals and families.

CP 6410. Principles of Real Estate, Land Development, and Private Sector Planning 3-0-3. Prerequisite: graduate standing or consent of instructor.
Location of cities and land uses within cities; land development; market analysis and economic feasibility studies; impact of changing tax laws on private sector developers.

CP 6400. Principles of Environmental and Energy Planning 3-0-3. Prerequisite: graduate standing or consent of instructor.
Identification and analysis of air, water, noise, and spatial pollution; energy management and its influence on urban development. Environmental controls and management programs evaluated.

Exposes and analyzes goals and objectives of selected local and state growth management techniques and multitude of federal land use policies.

CP 6520. Housing Economics and Policy 3-0-3. Prerequisite: graduate standing or consent of instructor.
Detailed examination of operation of local housing markets and national, state, regional, and local policies intended to influence those markets.

CP 6530. The Practice of Urban Planning 3-0-3. Prerequisite: graduate standing.
Study of history of planning profession, ethical standards for practice, public/private sector office procedures, professional societies, and future directions for practice.

CP 6752. Economic Aspects of Urban and Regional Planning I 3-0-3. Prerequisite: senior or graduate standing.
Introduction to cash-flow and discounting techniques. Micro-economics in project formulation and evaluation. Applications from welfare economics, project analysis, cost allocation.

CP 6754. Economic Aspects of Urban and Regional Planning II 3-0-3. Prerequisite: CP 6753.
Principles of resource allocation, benefit-cost analysis, urban and regional project formulation, justification, and application of computer simulation techniques to economic and resource allocation.

CP 7000. Master's Thesis Credit to be arranged.
A research problem in city planning, selected by the student in consultation with the graduate staff. Requires one full quarter of work as a minimum with technical direction available from the graduate staff.

CP 8011-21-31-41-51. Seminar – City Planning 1-0-1 each (audit only). Prerequisite: graduate standing and consent of the College.
CP 8103. Industrial Design I 3-0-3.
Credit to be arranged.
A research problem in city planning, selected by the student in consultation with the graduate staff. Requires one full quarter of work as a minimum with technical direction available from the graduate staff.

CP 8106. Special Topics 2-0-2.
CP 8590-01-02-03-04. Special Problems Credit to be arranged.

INDUSTRIAL DESIGN
A history of design, technology, and innovation, with emphasis on their influence in historic cultures. Open to all students.

Use of materials and processes designers use to communicate their ideas. Graphic techniques. Use of hand and power tools with wood, metals, and plastics. Modem making techniques. Use of working drawings.

Lettering, typography, and package design, as well as industrial design problems.

Production methods and their relation to design. Includes the study of major mass production techniques involved in manufacturing products and packaging through use of lectures, research, and field trips to production facilities.


ID 4002-3. Industrial Design II, III 1-12-5 each. Prerequisite: ID 3003.
Advanced industrial design problems, accentuating individual work in special areas of concentration.

ID 4101. Industrial Design I 1-12-5. Prerequisite: ID 3003.
Product development – advanced industrial design problems, emphasizing individual work in special areas of concentration.

ID 4451. Professional Practice of Industrial Design 3-0-3. Prerequisite: none.
Principles of consulting and corporate design office organization and project management relating to the practice of industrial design.

ID 4853. Special Topics – Industrial Design 3-0-3.

ID 4911. Special Problems – Visual Communications – Industrial Design Credit to be arranged.

ID 4951-52-53. Special Problems – Industrial Design Credit to be arranged.
Dean — William M. Sangster; Associate Dean — W. Denney Freeston; Assistants to the Dean — Carolyn C. Chesnutt, Madelyne Watson; Director of Special Programs — Lytia Howard.

General Information
The College of Engineering comprises nine degree-granting schools of instruction and research. The schools offer programs of study and research leading to bachelor's, master's, and doctoral degrees. Certain of the schools also offer programs in one or more subdisciplines or subspecialties. These degree offerings are summarized in an accompanying table.

The programs in engineering are designed to provide a fundamental understanding of the engineering sciences, which are based on mathematics and the natural sciences, of the basic concepts of the humanities and social sciences, and an understanding of the manner in which these elements are interwoven in engineering practice. Each curriculum provides enough flexibility through elective course opportunities to permit a certain amount of program individualism while meeting basic requirements.

Students who wish to study engineering but are undecided as to a specific engineering degree program may, for their freshman year, be classified as Undecided Engineering College (UEC) students and receive advisement from the Office of the Dean of Engineering. Course work for Undecided Engineering students will focus on the areas of mathematics, chemistry, physics, humanities, and social science, as does the first year course work for all engineering degree programs. Transfer from the undecided category to schools (majors) with space limitations may not be possible for students with cumulative grade-point averages below set minimums.

### College of Engineering Degree Programs

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<th>Aerospace Engineering</th>
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<th>M</th>
<th>PhD</th>
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</table>

### Freshman Engineering Electives

Any of the following courses are acceptable for credit as freshman engineering electives in all curricula in engineering: EGR 1170, AE 1351, CERE 1010, CHE 1110, 1750, CE 1503, EE 1010, 1011, 1750, ESM 1101, 1750, ME 1750, NE 1010, 1100, TEX 1100.

### Multidisciplinary Programs in Engineering

In addition to its degree programs, the College of Engineering provides opportunities for specialized study in engineering through its multidisciplinary certificate program offerings. Any student in good academic standing who is pursuing a degree in one of the participating schools of the Engineering College or a participating school from any of the other colleges may select elective courses and the subjects of special problems to satisfy simultaneously both the requirements of his or her major degree program and those of a specialized multidisciplinary program. Upon graduation, the student receives both the degree in the major field of study and a certificate attesting to successful completion of the particular related multidisciplinary program.

The table on page 78 shows both currently available multidisciplinary program offerings and those that are in the planning stage (identified by asterisks), as well as the degree levels of the programs.

### General Requirements of Undergraduate Multidisciplinary Programs

The specific design of the multidisciplinary program of any participating undergraduate student, while individualized, must meet certain general requirements as well as requirements that are specific to that multidisciplinary area. The general (minimum) undergraduate multidisciplinary requirements are as follows: (1) the program must relate the student's major area to the given multidisciplinary area; (2) courses must be taken under more than one academic unit; (3) at least four courses and twelve credit hours (not required by name and number in the student's major) must be taken in a coherent program; (4) at least three of those courses and nine credit hours must be at the 3000 level or higher; (5) at least two of those courses and six credit hours must be outside the major field (crosslisted courses may be counted outside the student's major); (6) a grade of C or better must be earned in each course counting toward a multidisciplinary certificate.

### General Requirements of Graduate Multidisciplinary Programs

The specific design of the multidisciplinary program of any participating graduate student, while individualized, must meet certain general requirements as well as requirements that are specific to that multidisciplinary area. The general (minimum) graduate multidisciplinary requirements are the same as those listed above for the undergraduate programs, with the following exceptions: (1) at least three of the coherent multidisciplinary program courses as well as nine credit hours must be at the 6000 level or higher; (2) a grade of B or better must be earned in each course counting toward a multidisciplinary certificate; (3) students at the doctoral level must, on an individual basis, meet additional requirements specified by the student's doctoral committee, consistent with a program beyond the master's level whose objective is to develop a doctoral level multidisciplinary program.

Interested students may obtain detailed information on the various undergraduate-level and graduate-level multidisciplinary programs from the main office of the school in which they are enrolled and through the Office of the Dean, College of Engineering.

### Computer Integrated Manufacturing Systems Program

The Computer Integrated Manufacturing Systems (CIMS) multidisciplinary program awards a certificate for study at the graduate level of the integration of design, information and material processing, and management in manufacturing systems. Eight academic units participate in the program: Aerospace Engineering, Chemical Engineering, Civil Engineering, Electrical Engineering, Industrial and Systems Engineering, Information and Computer Science, Mechanical Engineering, and the College of Management. Two core courses, twenty-four hours of electives (eighteen under the thesis option), a seminar series, and a project make up the certificate requirements. Financial support is available to highly qualified students in the form of assistantships. Industry
interaction and unique laboratory opportunities are available in the program.

**Multidisciplinary Programs**

<table>
<thead>
<tr>
<th>Multidisciplinary Program</th>
<th>Related Degree Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acoustical Engineering</td>
<td>M PhD</td>
</tr>
<tr>
<td>Bioengineering</td>
<td>B M PhD</td>
</tr>
<tr>
<td>Computer Engineering</td>
<td>M PhD</td>
</tr>
<tr>
<td>Computer Integrated</td>
<td>Manufacturing Systems</td>
</tr>
<tr>
<td>Energy Engineering</td>
<td>B M PhD</td>
</tr>
<tr>
<td>Engineering Design</td>
<td>M* PhD*</td>
</tr>
<tr>
<td>Environmental Studies</td>
<td>M* PhD*</td>
</tr>
<tr>
<td>Materials Engineering</td>
<td>B M PhD</td>
</tr>
<tr>
<td>Mineral Engineering</td>
<td>B M PhD</td>
</tr>
<tr>
<td>Plastics Engineering</td>
<td>B M PhD</td>
</tr>
<tr>
<td>Pulp and Paper Engineering</td>
<td>B M PhD</td>
</tr>
<tr>
<td>Structures Engineering</td>
<td>M PhD</td>
</tr>
<tr>
<td>Systems Engineering</td>
<td>M* PhD*</td>
</tr>
<tr>
<td>Transportation Engineering</td>
<td>M* PhD*</td>
</tr>
</tbody>
</table>

* = Programs in Planning Stage

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**School of Aerospace Engineering**

**Daniel Guggenheim School of Aeronautics, Established in 1930**


**General Information**

The School of Aerospace Engineering prepares students at the bachelor's, master's, and doctoral levels for a career in vehicle engineering with primary emphasis on flight vehicles. The school is housed in three buildings having a floor space of 85,000 square feet, the majority of which is devoted to instructional and research laboratories.

**Undergraduate Programs**

The first two years focus on course work in the areas of chemistry, mathematics, physics, humanities, and social sciences. The third and fourth years emphasize aerospace disciplines and related engineering sciences. The undergraduate curriculum is designed to provide each student with a general background for either industry or graduate school at the end of four years. The program stresses both the theoretical and experimental aspects of aerospace engineering.

A certain degree of specialization is available to undergraduate students through the proper choice of electives, certain substitutions for required courses, or a combination of both options, depending on the student's abilities and career objectives. These specialized disciplines are acoustics, aerelasticity, aerospace vehicle design, bioengineering, experimentation and instrumentation, fluid dynamics of pollution, helicopters and V/STOL aircraft, propulsion, structural dynamics, structures, and supersonic and hypersonic vehicles.

A pre-med track is also available to undergraduate students. This program requires an additional academic year of chemistry and one academic year of biology. Students may substitute these courses for the electives and for certain required courses in the present curriculum.

**Graduate Programs**

The graduate programs at both the master's and doctoral levels are flexible so that students may tailor their course and research work to individual career objectives. A minimum of fifty credit hours is required for the master's degree. The following areas of specialty are available.

**Aerelasticity**

Dynamic response and loads, flutter, servo-aerelastic instabilities and control, static aerelastic instabilities and loading, unsteady aerodynamics—V/STOL and conventional aircraft, and vibrational characteristics of vehicles.

**Fluid Mechanics**

Computational fluid dynamics, helicopter aerodynamics, laminar and turbulent flows, plasma and reacting gas dynamics, statistical theory of turbulence, and V/STOL aircraft.

**Propulsion**

Combustion instability, external burning, propulsion system noise, solid rocket propellant research, and supersonic combustion.

**Structures**

Buckling and postbuckling of structures, composites, elastic and inelastic stress analysis, fracture mechanics, fatigue behavior, structural reliability and statistical methods of structural analysis, vibration and dynamic stability of structural elements, wave propagation, and use of acoustic emission methods.

**Urban and Societal Engineering**

Air pollution, biomechanics, fire research, and noise pollution.

Facilities for each of the above academic areas are housed in the aerospace laboratories and include low-speed, high-speed, MHD, and low-density wind tunnels; anechoic chamber; combustion chamber; combustion bomb; helicopter test stand; high- and low-temperature test machines; fatigue and creep machines; humidity chamber; environmental test chamber; analog and digital computers; data acquisition systems; Fourier analyzers; scanning electron microscope and associated instrumentation, such as transducers, lasers, and tape recorders. These facilities are supported by extremely competent personnel and a well-equipped instrument lab and machine shop.

**Curriculum**

**Freshman Year**

<table>
<thead>
<tr>
<th>Course</th>
<th>1st Q.</th>
<th>2nd Q.</th>
<th>3rd Q.</th>
</tr>
</thead>
<tbody>
<tr>
<td>EGR 1170</td>
<td>Intro to Visual Communication and Engineering Design I (2-3-3), and one of the engineering electives</td>
<td>X-X-3</td>
<td>X-X-3</td>
</tr>
<tr>
<td>CHEM 1101-2</td>
<td>Organic Chemistry</td>
<td>4-3-5</td>
<td>4-3-5</td>
</tr>
<tr>
<td>ENGL 1001-2</td>
<td>Analysis of Literature and Language</td>
<td>3-0-3</td>
<td>3-0-3</td>
</tr>
<tr>
<td>MATH 1307-8-9</td>
<td>Calculus I, II, III</td>
<td>5-0-5</td>
<td>5-0-5</td>
</tr>
<tr>
<td>PHYS 2121</td>
<td>Physics</td>
<td>4-3-5</td>
<td></td>
</tr>
<tr>
<td>Electives</td>
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<td>Electives</td>
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<tr>
<td>Electives</td>
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<td></td>
</tr>
<tr>
<td>Physical Education</td>
<td>X-X-2</td>
<td>X-X-1</td>
<td>X-X-1</td>
</tr>
<tr>
<td>Totals</td>
<td>X-X-18</td>
<td>X-X-17</td>
<td>X-X-20</td>
</tr>
</tbody>
</table>

**Sophomore Year**

<table>
<thead>
<tr>
<th>Course</th>
<th>1st Q.</th>
<th>2nd Q.</th>
<th>3rd Q.</th>
</tr>
</thead>
<tbody>
<tr>
<td>AE 2101</td>
<td>Introduction to Aircraft Structures</td>
<td>4-0-4</td>
<td></td>
</tr>
<tr>
<td>AE 2603</td>
<td>Digital Computers</td>
<td>1-6-3</td>
<td></td>
</tr>
<tr>
<td>ESM 2201</td>
<td>Statics</td>
<td>3-0-3</td>
<td></td>
</tr>
<tr>
<td>ESM 3301</td>
<td>Dynamics I</td>
<td>3-0-3</td>
<td></td>
</tr>
</tbody>
</table>

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Curricula and Courses of Instruction
Courses of Instruction

AE 1750. Introduction to Bioengineering 3-0-3.
Introduction to aspects of science and technology pertinent to bioengineering. Also taught as EE 1750, ESM 1750, and ME 1750.

AE 2101. Introduction to Aircraft Structures 4-0-4. Prerequisite: ESM 2201, 2.0 overall average. Prerequisite or corequisite: MATH 2308.
Introduction to elements of structural mechanics which are used in the design of aircraft and missile structures.

AE 2603. Computer Applications in Aerospace Engineering 1-6-3. Prerequisite: MATH 1309.
Description of the components of a modern digital computing system. Elementary FORTRAN programming. Introduction to aerospace engineering applications.
Text: at the level of Rivelio, Theory and Analysis of Flight Structures.

Text: at the level of Rivello, Foundations of Aerodynamics.

AE 3110. Structures Lab 1-3-2.
Introduction to stability analysis with applications to columns and plates. Principle of virtual work and energy principles.
Text: at the level of Rivelio, Theory and Analysis of Flight Structures.

AE 3111. Structures Lab 1-3-2. Prerequisite or corequisite: AE 2101.
Introduction to theory of measurements and to methods for determining mechanical properties.

AE 3750. Introduction to Biofluid Dynamics 3-0-3. Prerequisites: MATH 2309, PHYS 2123.
Study of blood flow in the cardiovascular system, with emphasis on the modeling of such flows and the potential of flow studies for clinical research application. Also taught as ESM 3750 and CHE 3750.

AE 4000. Fluid Mechanics IV 3-4-5. Prerequisites: AE 3000, AE 3001, AE 3002.
Finite wing theory, two-dimensional subsonic and supersonic compressible flows, supersonic flow around bodies of revolution and an introduction to transonic and hypersonic.
Text: at the level of Kuether and Chow, Foundations of Aerodynamics.

AE 4101. Analysis of Thin-walled Structural Elements 3-0-3. Prerequisite: AE 3103.

AE 4102. Selected Topics in the Analysis of Aircraft Structures 3-0-3. Prerequisites: AE 3102, ESM 4210. Prerequisite or corequisite: MATH 2309.
Two-dimensional incompressible flow theory, superpositioning and conformal transformations, with applications to flow around bodies and to airfoil theory.
Text: at the level of Kuether and Chow, Foundations of Aerodynamics.

AE 4200. Vibration and Flutter 3-0-3. Prerequisites: AE 3002, ESM 4210. Prerequisite or corequisite: MATH 4582.
Structural dynamics of one-dimensional systems. Analysis of static aeroelastic phenomena and flutter. Equations of motion for complete aeroelastic system and solution techniques.
AE 4251. Jet Propulsion 
4-4-3. Prerequisite: AE 4000.

The theory and principles of jet propulsion. The mechanics and thermodynamics of combustion. Component and cycle analysis. Engine performance characteristics.

Text: at the level of Hill and Peterson, Mechanics and Thermodynamics of Propulsion.

AE 4350-1. Aerospace Engineering Design Project I, II
2-6-4 each. Prerequisite: AE 4000. Prerequisite or corequisite: AE 4410, AE 4500.

Preliminary design or case study of an aerospace system such as a complete flight vehicle, a propulsion system, a structural system, or a control system.

AE 4400. Introduction to Propeller and Rotor Theory
3-0-3. Prerequisite or corequisite: AE 4000 or consent of School.

A study of the theory and equations used in the design of propellers and helicopter rotors.

Text: at the level of Gessow and Myers, Aerodynamics of the Helicopter.

AE 4410. Vehicle Performance
3-0-3. Prerequisites: AE 3001, AE 3002. Prerequisite or corequisite: AE 4000.

A study of basic aerodynamic-vehicle performance including drag estimation, horsepower-thrust required and available, basic point and path performance, special performance items, maneuvers and resultant air loads.

AE 4500. Stability and Control
5-0-5. Prerequisites: AE 4000, ESM 4210.

Principles of static lateral and longitudinal stability and studies of the equations and methods used in analysis. Applications to airplane and missile systems.

Text: at the level of Perkins and Hage, Airplane Performance, Stability and Control.

AE 4550. Instrumentation for Experimental Research I
2-3-3. Prerequisite: consent of School.

Laboratory treatment of major and ancillary instrumentation used in solid and fluid mechanics research, voltage, current, resistance measurement, transducers, amplifiers, oscilloscopes, recording equipment.

AE 4551. Instrumentation for Experimental Research II
2-3-3. Prerequisite: AE 4550 or consent of School.

Advanced treatment of laboratory instrumentation for research, analysis, and application of operational amplifiers, filters and bandpass conditioners, elementary digital circuits, computer systems for data acquisition.

AE 4760. Engineering Acoustics and Noise Control I
3-0-3. Prerequisite: AE 4761 or equivalent.

AE 4761. Engineering Acoustics and Noise Control II
3-0-3. Prerequisite: AE 4760 or equivalent.

Continuation of AE 4760 emphasizing techniques for the solution of noise problems. Vibration isolation, energy absorption, dissipative and reactive mufflers, exhaust, barriers, properties of materials, panel damping. Also taught as ESM 4761, ME 4761.

AE 4770. Structural Integrity and Durability
3-0-3. Prerequisite: ESM 3301 or AE 2101.

Simple stress-concentration problems involving plastic deformation, residual stresses, hysteresis, creep, and relaxation. Introduction to fatigue and fracture mechanics. Crash growth calculations and wearout models.

AE 4893-13-23-33-43-53. Special Topics
3-0-0 each. Prerequisite: consent of School.

Course material devoted to special topics of current interest, treatment of new developments in various areas of aerospace engineering.

AE 4804-14-24-34-44-54. Special Topics
4-0-0 each. Prerequisite: consent of School.

Course material devoted to special topics of current interest, treatment of new developments in various areas of aerospace engineering.

AE 4805-15-25-35-45-55. Special Topics
5-0-0 each. Prerequisite: consent of School.

Course material devoted to special topics of current interest, treatment of new developments in various areas of aerospace engineering.

AE 4900-12. Special Problems in Aerospace Engineering
Credit to be arranged. Prerequisites: third quarter junior or senior standing and approval of director.

Research on a problem selected in consultation with a faculty member. A brief description, endorsed by the adviser, must be approved by the school director.

AE 6001. Foundations of Fluid Mechanics
4-0-4. Prerequisite: consent of School.

Development of the conservation equations of a multicomponent, reacting fluid from both the continuum and molecular viewpoints. Stress tensor, heat transfer vector, and diffusion velocity.


AE 6010. Viscous Flow I
3-0-3. Prerequisite: AE 6001 or consent of School.

Exact solutions of Navier-Stokes equations, Stokes flow, boundary layer equations, similarity solutions and integral methods for incompressible flow, compressible laminar boundary layer, viscous hypersonic flow.

AE 6011. Viscous Flow II
3-0-3. Prerequisite: AE 6010 or consent of School.

Transition from laminar to turbulent flow, equations of motion for turbulent flows, incompressible boundary layers, compressibility and heat transfer, semi-empirical methods, wakes and jets.

AE 6020. Elements of Compressible Flow
3-0-3. Prerequisite: consent of School.

Defining equations for inviscid compressible flows, method of characteristics for unsteady one-dimensional and steady two-dimensional and axially symmetric flows, nozzle design, conical flow.

AE 6021. Advanced Compressible Flow Theory I
3-0-3. Prerequisite: AE 6020 or consent of School.

The linearized potential equation, thin airfoil theory, similarity rules, linear theory for axially symmetric and three-dimensional flows.

AE 6022. Advanced Compressible Flow Theory II
3-0-3. Prerequisite: AE 6021.

Mixed subsonic-supersonic flows, transonic similarity rule, two-dimensional and axially symmetric bodies in transonic flow, selected topics.

AE 6023. Hypersonic Flow Theory
3-0-3. Prerequisite: AE 6021 or consent of School.

Hypersonic similarity rule, hypersonic small disturbance theory, Newtonian flow theory and other approximate methods, boundary layer interaction, the blunt body problem.

AE 6030. Advanced Potential Flow I
3-0-3. Prerequisite: AE 6021.

Development of the nonlinear and linearized unsteady potential flow equations. Solutions to incompressible flow problems of airfoils and wings undergoing steady, oscillatory and arbitrary motions.

AE 6031. Advanced Potential Flow II
3-0-3. Prerequisite: AE 6030.

Formulation of aerodynamic influence coefficients, solutions to subsonic, supersonic, and hypersonic flow problems of wings and bodies experiencing oscillatory and arbitrary motions.

AE 6050. High-temperature Gas Dynamics I
3-0-3. Prerequisite: AE 6260 or consent of School.

Real gas effects. Equilibrium properties and rate processes of high-temperature gases. Equilibrium and frozen flows, normal and oblique shocks, nozzle flows, Prandtl-Meyer flows.

AE 6051. High-temperature Gas Dynamics II
3-0-3. Prerequisite: AE 6050.

Acoustic equations and rate equations. Vibrational and chemical nonequilibrium flows, normal and oblique shock structures, theory of nonequilibrium characteristics, nonequilibrium acoustic waves, flow over corners.

AE 6100. Advanced Structural Analysis I
3-0-3. Prerequisite: AE 3104 or consent of School.

Stability of mechanical models, elastic bars, and frames by kinetic and energy approaches, approximate methods for critical loads, dynamic stability, and inelastic effects.

AE 6101. Advanced Structural Analysis II
3-0-3. Prerequisite: AE 6100 or consent of School.

Buckling of plates, torsional instability of thin section columns, lateral buckling of beams, beams on elastic foundations, further discussion of dynamic stability.

AE 6102. Advanced Structural Analysis III
3-0-3. Prerequisite: AE 6100, ESM 6572, or consent of School.

Stability of plates, cylindrical shells, edge effects, complete spheres and shallow spherical caps, recent developments.

AE 6103. Advanced Structural Analysis IV
3-0-3. Prerequisite: AE 6100 or consent of School.

Principle of virtual work. Concepts of potential energy and complementary energy, weighted residuals, applications in approximate solutions. Discussion of Hookean material, including thermal strains.

AE 6104. Advanced Structural Analysis V
3-0-3. Prerequisite: AE 6103 or consent of School.

Introduction to finite element analysis, with emphasis on the displacement analysis of structures. Applications to static equilibrium, vibration and stability, nonlinear formulation, solution techniques.

AE 6105. Aerospace Structures Laboratory
1-3-0. Prerequisite: AE 6104 or consent of School.

Development of practical methods for experimental mechanics, design and execution of experiments, measurement of displacement, strain, force, acceleration, temperature, design of transducers, and instrumentation systems.

AE 6120. Thermal Effects in Structures I
3-0-3. Prerequisite: MATH 4582.

Analysis of heat transfer in structural elements, development, and use of approximate numerical and analytical solution procedures.

AE 6121. Thermal Effects in Structures II
3-0-3. Prerequisite: ESM 6321 or consent of School.

Analysis of thermally induced stresses in beams, plates and shells, formally induced instability in columns and plates, reduction in torsional rigidity.

AE 6122. Thermal Effects in Structures III
3-0-3. Prerequisite: ESM 6321 or consent of School.

Phenomenological and mechanistic interpretations of mechanical behavior of solids. Formulation and solution of problems involving elastic, plastic, linear, and nonlinear viscoelastic and viscoplastic behavior.

AE 6130. Structural Dynamics I
3-0-3. Prerequisite: AE 3103, ESM 4210.


AE 6131. Structural Dynamics II
3-0-3. Prerequisite: AE 6130.


AE 6200. Advanced Aerelasticity I
3-0-3. Prerequisite: AE 6130.

Static aerelastic analysis of flight vehicles, lifting surface and panel flutter analyses with applications. Dynamic response and load studies of flight vehicles using modal techniques.
AE 6201. Advanced Aeroelasticity II
3-0-3. Prerequisite: AE 6200.
Formulation of aeroelastic analyses associated with 
discrete and random dynamic loads, aeroelastic 
and structural instabilities of fixed- and rotating-wing flight 
vehicles.

AE 6202. Experimental Aeroelasticity
3-0-3. Prerequisite: AE 6200.
Analog computing techniques with applications, 
flexibility influence coefficient measurements. Vibration 
testing for modal identification, wind tunnel and inflight 
flutter tests including model scaling and construction.

AE 6203. Special Topics in Aeroelasticity
3-0-3. Prerequisite: AE 6200.
Current topics in aeroelasticity, unsteady aerodynamics, 
and structural dynamics are studied. The student 
presents both an oral and written report on two special-
ized current problems.

AE 6204. Special Topics in Aeroelasticity II
3-0-3. Prerequisite: AE 6200.
Continuation of AE 6203. Advanced problems in 
aeroelasticity, unsteady aerodynamics, or structural 
dynamics.

AE 6250. Rocket Propulsion I
3-0-3. Prerequisite: AE 4251.
Flight mechanics, performance of the ideal rocket 
engine. Properties and performance characteristics of 
chemical propellants, nozzle designs, and losses.

AE 6260. Thermodynamics of Gases
4-0-4. Prerequisite: consent of School.
Thermodynamics of reacting gases. Introductory 
quantum theory, statistical thermodynamics, and chemi-
cal kinetics.

AE 6261. Combustion I
3-0-3. Prerequisite: AE 6260 or consent of School.
Introductory chemical kinetics, explosions, Schub-
Zelovich formulation. Rankine-Hugoniot relations, 
detonations, and deflagrations.

AE 6262. Combustion II
3-0-3. Prerequisite: AE 6261.
Laminar diffusion flames and droplet burning. 
Laminar flame propagation in premixed gases, turbulent 
 flames, ignition quenching, and flamability limits. 
Chemical reactions in boundary layers.

AE 6400. Aerodynamics of the Helicopter I
3-0-3. Prerequisite: AE 4400.
Forward flight performance, derivation and study of 
the induced velocity relations and the flow field associ-
ated with helicopter rotors.

AE 6401. Aerodynamics of the Helicopter II
3-0-3. Prerequisite: AE 6400.
Vortex-wake theories for rotors with a finite number 
of blades, introduction to helicopter stability and con-
trol.

AE 6460. Aeroelastic Noise
3-0-3. Prerequisite: AE 6761.
Jet, boundary layer, combustion, propeller, and fan 
noise. Sonic boom, noise propagation from engines, and 
attemperation techniques.

AE 6500. Advanced Stability and Control
3-0-3. Prerequisite: AE 4500.
A study of feedback controls as applied to aircraft; 
root locus techniques and use of airframe transfer 
 functions are emphasized. Survey of the load alleviation 
problem.

AE 6760. Engineering Acoustics I
3-0-3. Prerequisite: consent of School.
Introductory analytical methods, stochastic processes, 
the wave equation in a compressible fluid, and problems 
in the radiation of sound. Also taught as ESM 6760 and 
ME 6760.

AE 6761. Engineering Acoustics II
3-0-3. Prerequisite: AE 6760.
Sound reflection and refraction, scattering and diffra-
cion, sound radiation, and duct acoustics. Also taught as 
ESM 6761 and ME 6761.

AE 6762. Engineering Acoustics III
3-0-3. Prerequisite: AE 6761.
Advanced duct acoustics, wave dispersion and attenu-
ation, acoustics in moving media, geometrical acoustics, 
nonlinear acoustics. Also taught as ESM 6762 and ME 
6762.

AE 6763. Noise Reduction and Control
3-0-3. Prerequisite: AE 4760 or equivalent and 6760.
Methods of noise reduction and control applied to 
systems in industry. Measurement of sound power, 
material acoustic properties, barriers, enclosures, 
nursery, vibration reduction, and damping methods. 
Also taught as ESM 6763 and ME 6763.

AE 6800. Numerical Fluid Dynamics I
3-0-3. Prerequisite: AE 6010 or consent of School.
Finite-difference and finite-element methods for the 
numerical solution of fluid dynamic equations. Current 
methods for the numerical solution of potential flow 
and boundary layer problems.

AE 6801. Numerical Fluid Dynamics II
3-0-3. Prerequisite: AE 6800.
Numerical methods of solution of boundary layer 
equation and Naiver-Stokes equations for time-
depending and steady flows. Accuracy, stability, and 
computational efficiency.

AE 7000. Master's Thesis
AE 7600. Perturbation Methods in Engineering 
Analysis
3-0-3. Prerequisite: consent of School.
Regular and singular perturbation theory, WKBJ 
method, and the method of weighted residuals. Problems 
drawn from fluid mechanics and structures.

AE 7750. Bio-Fluid Mechanics
3-0-3. Prerequisite: AE 6001 or ESM 6501-2 or consent of School.
A unified treatment on hemorheology, hemodynamics, 
pulsatile flows, microcirculation, joint lubrication, 
pulmonary physiology, etc., with emphasis on a quanti-
tive approach. Also taught as ESM 7750.

AE 7999. Preparation for Doctoral Qualifying Exams
Noncredit. Prerequisite: consent of director.

AE 8000. Seminar
1-0-1.

AE 8103-13-23-33-43-53. Special Topics
3-0-3 each. Prerequisite: consent of School.
Special topics of current interest, treatment of new 
developments in various areas of aerospace engineering.

AE 8104-14-24-34-44-54. Special Topics
3-0-3 each. Prerequisite: consent of School.
Special topics of current interest, treatment of new 
developments in various areas of aerospace engineering.

AE 8105-15-25-35-45-55. Special Topics
3-0-3 each. Prerequisite: consent of School.
Special topics of current interest, treatment of new 
developments in various areas of aerospace engineering.

AE 8500-1-2. Special Problems in Aerospace 
Engineering
Credit to be arranged. Prerequisite: consent of School.

AE 8503-4-5. Special Problems in Aerospace 
Engineering
Credit to be arranged.

AE 8999. Preparation for Doctoral Dissertation 
Noncredit. Prerequisite: consent of director.

AE 9000. Doctoral Thesis

School of 
Chemical Engineering

Established in 1901

Director and Professor—Gary W. Poehelein; 
Associate Director and Professor—Jude T. 
Somerfeld; Chemical Engineering Faculty: 
Professors—Eric J. Clayfield, Charles W. 
Gorton, Michael J. Matteson, John D. 
Muzzy, Robert J. Samuels, A. H. Peter 
Skelland, Amy S. Teja, Henderson C. 
Ward, Jack Winnick; Associate Professors— 
Agaram S. Abhiraman, Pradeep K. Agra-
ham, Joseph Schork, Fred Vogt; Adjunct 
Professors—Charles Aloisio, Samuel Brockway, George 
Fowles, Tudor Thomas.

General Information

Chemical engineers perform essential func-
tions in industries that convert raw materials into 
useful finished products by means of chemical and 
physical processes. Almost every major manufacturing industry employs chemical 
engineers in research, development, design, production, sales, consulting, 
and management positions. Industries that employ substantial numbers of chemical 
engineers include petroleum, petrochemical, pulp and paper, plastics, metallurgical, fiber, 
fertilizer, nuclear energy, space, rubber, food, photographic, heavy and fine chemi-
cal, mineral, pharmaceutical, textile, electronic, and dye. Energy problems and 
environmental and pollution control activities also require an increasing number of chemi-
cal engineers.

The School of Chemical Engineering offers programs leading to the degrees Bachelor of Chemical Engineering, Master of Science in Chemical Engineering, and Doctor of Philosophy. The doctoral program 
may concern either chemical engineering or metallurgy. Interdisciplinary programs and 
deignated and undesignated degrees are also available.

The following curriculum leads to the degree Bachelor of Chemical Engineering and 
seeks to train students not only for positions immediately upon graduation but also 
for additional study leading to the master's and doctoral degrees.

It is a regulation of the School of Chemical Engineering that any student who accumu-
lates a total of three or more grades of "F", "D", or "W" in required chemical engi-
neering courses will not be permitted to enroll in any more chemical engineering 
courses and/or will not be certified for graduation by the School. Exceptions to this 
regulation will be permitted only after the affected student submits a specific written 
petition for exemption from this regulation and approval of said petition by the faculty 
of the School of Chemical Engineering.
A six-week summer study program in the Department of Chemical Engineering of the University College London in London, England, was initiated in the summer quarter, 1975. Selected juniors who participate in this program are allowed twelve credit hours of free or technical electives, some of which may be substituted for selected chemical engineering laboratory and social science courses.

Students whose previous academic backgrounds differ substantially from that of Georgia Tech are strongly advised to consider lightened academic loads during their first several quarters at Georgia Tech. Such students may also wish to take advantage of the option of auditing one or two of the first sophmore courses in chemical engineering (CHE 2207 and 2208) before electing these required courses for credit.

The School of Chemical Engineering requires that all of its students have a working knowledge of the FORTRAN programming language before scheduling any sophomore-level courses.

**Graduate Programs**

The School of Chemical Engineering offers a graduate program of advanced study and research in chemical engineering. Chemical engineering graduate work can lead to the Master of Science and the Doctor of Philosophy degrees, both involving a combination of advanced-level courses and independent research or design work.

Master's degree candidates must complete a research or design thesis. Course selection for both the master's and doctoral degrees is quite flexible with individual plans of study developed for each student.

Research opportunities exist in a broad range of areas of importance to chemical engineers and society including air pollution control, biochemical engineering, polymer science, process design and simulation, chemical reaction engineering, development of alternate energy sources, biomedical engineering, pulp and paper engineering, transport phenomena, fine particle technology, minerals processing, thermodynamics, electrochemical engineering, and process control.

**Curriculum**

**Freshman Year**

<table>
<thead>
<tr>
<th>Course</th>
<th>1st Q.</th>
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<td>CHE 1101</td>
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<tr>
<td>Introduction to</td>
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<td>Analysis of Literature</td>
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<td>X-X-17</td>
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**Sophomore Year**

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<td>CHE 2207-8</td>
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<tr>
<td>Chemical Process</td>
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**Junior Year**

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</tr>
<tr>
<td>Heat Transfer</td>
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¹CHEM 1111-2, advanced-level chemistry, is required for all chemical engineering majors. Students transferring into chemical engineering from other curricula not requiring the advanced-level chemistry will be allowed to substitute CHEM 1101-2 for CHEM 1111-2, respectively, if taken prior to transferring.

²ENGL 1001-2 and ENGL 2xxx, with the latter course to be selected from ENGL 2101, 2201, 2301, or 2401, are required for all chemical engineering majors and satisfy nine hours of the total humanities requirement of eighteen hours. Students transferring into chemical engineering from other curricula not requiring these specific English courses or students granted advanced placement for these courses will be allowed to substitute any nine hours of humanities for these English requirements. International students may substitute FL 1031-2 for CHEM 1101-2, respectively, if taken prior to transferring.

³Students may elect the course MATH 4805 (Differential Equations for Chemical Engineers, a five-hour course) as an elective.

⁴See "Curricula and Courses of Instruction," College of Engineering section, for acceptable freshman engineering electives.

⁵See "Information for Undergraduate Students," Humanities and Social Sciences Electives, for "Information for Undergraduate Students," Humanities and Social Sciences Requirements, for the College of Engineering requirement and a listing of acceptable electives in these two groups (also see Note 2). Students should also see the Constitution and History Examinations section in "Information for Undergraduate Students." Modern language is recommended for students considering graduate work.

Technical Electives—The technical elective requirement of the School of Chemical Engineering may be satisfied by any twelve hours of advanced technical or scientific courses provided the course is not repetitions of a previous course. A suggested list of technical electives is available from the chemical engineering office, and all questions concerning this requirement should be directed to the chemical engineering office. It is recommended that the technical electives be taken in the junior and senior years.

Free Electives—Fifteen hours of free electives are provided to a student who will be able to pursue specific interests. See the ROTC and Physical Education Credit sections for the maximum hours in these areas that may be applied toward degree requirements. If six credit hours of basic ROTC are elected, they should be scheduled beginning the first quarter the student is enrolled. No course which covers the same material as other courses in a student's plan of study can be used as a free elective.

Students may elect the course MATH 4805 (Differential Equations for Chemical Engineers, a five-hour course) in place of the required CHE 2210 (a three-hour course). The additional two hours from MATH 4805 may be counted for free or technical elective credit. Chemical engineering students may not receive credit for both MATH 4805 and either MATH 2309 or MATH 3308.

To be selected from EE 3702 (Elementary Electronics, 2-0-2), EE 3703 (Electric Power Conversion, 2-0-2), or EE 3400 (Instrumentation Laboratory, 1-3-2).
CHE Design Elective: X-X-3

CHE 4434
Plant Design: 1-6-3

CHE 4416
Process Control: 3-3-4

Electives: 9-0-9 9-0-9 12-0-12

Totals: 16-3-17 X-X-17 13-6-15

Multidisciplinary Programs
See table on page 78.

Courses of Instruction

CHE 1101. Introduction to Chemical Engineering 1-0-1
An orientation to chemical engineering. Nature of chemical engineering, the types of opportunities available, and the requirements for graduation and a successful career.

CHE 1110. Elements of Chemical Engineering Design 2-3-3
For freshmen only or with consent of School.
An introduction to chemical engineering design in which simplified problems of current interest are used as a basis for a design project. Basics of FORTRAN programming.

CHE 1750. Introduction to Bioengineering 2-3-3
A continuation of CHE 2207. The energy balance is developed. Thermophysical and thermochemical properties are discussed. Emphasis is on the application of combined material and energy balances to steady and unsteady state physical and chemical processes.
Text: at the level of Felder and Rousseau, Elementary Principles of Chemical Processes.

CHE 2110. Chemical Engineering Analysis 3-0-3
Prerequisite: knowledge of FORTRAN programming. Corequisite: CHE 2208.
Quantitative analysis of chemical engineering processes. Numerical methods are introduced and applied to the solution of chemical engineering problems. Emphasis is placed on solving problems by digital computer.

CHE 2310. Fluid Mechanics 3-0-3
Corequisite: CHE 2208.
Fundamental principles and applications of momentum transfer. The analysis of chemical engineering processes and operations involving fluid flow.

CHE 3302. Transport Phenomena Laboratory I 0-3-1
Corequisite: CHE 2310.
Laboratory experiments in momentum and energy transfer.

CHE 3303. Transport Phenomena Laboratory II 3-0-3
Corequisite: CHE 3311.
Laboratory experiments in heat and mass transfer.

CHE 3309. Unit Operations Laboratory I 0-3-1
Prerequisite: CHE 3313.
Laboratory experiments in stagewise operations.

CHE 3310. Unit Operations Laboratory II 0-3-1
Prerequisite: CHE 3312.
Laboratory experiments in diffusional processes.

CHE 3311. Heat Transfer 3-0-3
Corequisites: CHE 2310, CHE 3320.
Fundamental principles and applications of energy transfer. The analysis of chemical engineering processes and operations involving heat transfer.
Text: at the level of Incropera and DeWitt, Fundamentals of Heat Transfer.

CHE 3312. Mass Transfer 3-0-3
Corequisites: CHE 2310, CHE 3320.
Fundamental principles and applications of mass transfer. The analysis of chemical engineering processes and operations involving mass transfer.

CHE 3313. Stagewise Operations 3-0-3
Corequisite: CHE 2208.
Principles of thermodynamics with industrial applications. Applications of first and second laws, engines, air conditioning, turbines, equations of state, fluid properties, corresponding states.

CHE 3320. Chemical Engineering Thermodynamics I 3-0-3
Prerequisite: CHE 2208.
Principles of thermodynamics with industrial applications. Phase equilibria, fugacity, activity, mixtures, nonideal solutions, gas solubility, reaction equilibria.
Text: at the level of Van Ness and Abbott, Classical Thermodynamics of Nonelectrolyte Solutions.

CHE 3750. Introduction to Biofluid Dynamics 3-0-3
Prerequisite: MATH 2309, PHYS 2123, or consent of instructor.
Study of blood flow in the cardiovascular system, with emphasis on the modeling of such flows and the potential of flow studies for clinical research applications.
Also taught as AE 3750 and ESM 3750.

CHE 4111. Mineral Engineering: Fossil Fuels 3-0-3
An introductory course in fossil fuels. Gives majors in engineering a background in fuels and raw materials.

CHE 4414. Air Pollution Control 3-0-3
Application of mass transfer principles of the design of pollution control systems utilizing adsorption, absorption, filtration, and precipitation. Other topics are process optimization, fuel pretreatment.
Text: at the level of Work and Warner, Air Pollution—Its Origin and Control.

CHE 4415. Reactor Design 3-0-3
Prerequisites: CHE 3212, CHEM 3313, 3413.
Kinetics and mechanisms of industrial chemical reactions. Effects of temperature, pressure, and concentrations on the rates of chemical reactions. Design of batch, backmix, tubular, and semibatch reactors.
Text: at the level of Hill, An Introduction to Chemical Engineering Kinetics and Reactor Design.

CHE 4416. Process Control 3-3-4
A study of the synthesis and operation of large-scale computer systems for steady-state simulation of chemical processes as a design tool.
Text: at the level of Seader, FLOWTRAN Simulation—An Introduction and the PROCESS Input Manual.

CHE 4453. Polymerization Process Analysis 3-0-3
Prerequisites: MET 3301, CHE 4415, or consent of School.
Polymerization processes are analyzed with regard to reaction mechanisms, kinetics, and reactor design.

CHE 4455. Plastics Industry Manufacturing Policy 3-0-3
Prerequisite: consent of School.
Case studies of practical problems contributed by industry concerning plastics manufacturing, marketing, and management. Decision-making processes in the plastics industry are emphasized.
Text: at the level of Skinner and Rogers, Manufacturing Policy in the Plastics Industry.

CHE 4750. Polymer Science and Engineering 1 3-0-3
Prerequisites: CHEM 1102, PHYS 2123.
An introduction to the chemistry and structure of polymers. Polymerization processes, major polymer systems, and methods of polymer identification are presented. Also taught as TEXT 4750.
Text: at the level of Rodriguez, Principles of Polymer Systems.

CHE 4751. Polymer Science and Engineering II 3-0-3
Prerequisites: CHEM 1102, PHYS 2123.
An introduction to the physical states and transitions, fabrication processes, and mechanical properties of polymers. Also taught as TEXT 4751.
Text: at the level of Rodriguez, Principles of Polymer Systems.

CHE 4753. Survey of Pulp and Paper Technology 3-0-3
A survey is made of the mechanical systems used in paper manufacture. The chemistry of pulp preparation and nonfibrous additives is outlined. Also taught as TEXT 4753.

CHE 4760. Polymer Science and Engineering Laboratory 1-6-3
Corequisite: CHE 4751.
Experiments in polymerization, processing, and property evaluation of polymers. Also taught as TEXT 4760.
A survey of the processes in a Kraft pulp mill necessary to convert raw material to sulfate pulp. Wood preparation, cooking, and bleaching. The chemical and mechanical characteristics of Kraft pulp and chemical recovery processes. Also taught as ME 4771.

The major pulping processes other than Kraft pulping. General knowledge of the various factors affecting each pulping process and pulp bleaching. The unique advantages and disadvantages of each pulping and bleaching process. Also taught as ME 4772.

The processes in the fabrication of paper and paper products from pulp. The effects on paper properties of chemical and mechanical pretreatment of pulp. The measurement of paper properties. Also taught as ME 4773 and TEXT 4773.

Methods of control of gaseous, liquid, and solid wastes from pulp and paper mill operations. Major biological, chemical, and physical methods for treatment of waste streams.

CHE 4801-2-3-4-5-6. Special Topics 1 through 6 credit hours, respectively. Prerequisite: consent of School.
Topics relevant to chemical engineering, not currently covered in the undergraduate curriculum, are presented as demand or interest warrants.

CHE 4901-2-3. Special Problems Credit to be arranged. Prerequisite: CHE 3311.
The student is given an opportunity to develop initiative and to apply fundamental principles by doing individual or original laboratory or theoretical investigations of a chemical engineering problem.

CHE 6001. Biochemical Engineering I 3-0-3. Prerequisite: consent of instructor.
Engineering aspects of enzyme systems. Transport phenomena in biological systems and elementary biological reactor design.

CHE 6002. Biochemical Engineering II 3-0-3. Prerequisite: consent of School.
Advanced Biological Reactor Design. Analysis of complex biological systems.

CHE 6601. Chemical Engineering Thermodynamics I 3-0-3. Prerequisite: CHE 3321 or consent of School.
Text: at the level of Prausnitz, Molecular Thermodynamics of Fluid Phase Equilibria.

CHE 6602. Chemical Engineering Thermodynamics II 3-0-3. Prerequisite: CHE 6601 or consent of School.
Text: at the level of Prausnitz, Molecular Thermodynamics of Fluid Phase Equilibria.

CHE 6607. Thermochemical Conversion 3-0-3. Prerequisite: CHE 4434 or consent of School.
Thermochemical conversion to fuels or chemical feedstocks with emphasis on feed materials of solid wastes and biomass.

CHE 6610. Aerosol Technology 3-0-3. Prerequisite: consent of School.
Presents basic concepts describing the behavior of dispersed particles. Includes generation, sampling and size analysis, diffusion, coagulation, settling, kinetics and dynamics, electrostatic and optical properties.
Text: at the level of Mencer, Aerosol Technology.

CHE 6611. Industrial Emission Control 3-0-3. Prerequisite: consent of School.
Air quality criteria, ambient and emission standards, and industrial sources are analyzed. Recovery and utilization of waste gaseous and particulate matter are presented.
Text: at the level of Crawford, Air Pollution Control Theory.

CHE 6612. Atmospheric Reactions 3-0-3. Prerequisite: consent of School.
The principles of atmospheric chemical and photochemical reactions, including primary and derived air pollutants, sources and sinks of carbon, nitrogen, sulfur, and oxygen compounds.
Text: at the level of Seinfeld, Air Pollution, Physical and Chemical Fundamentals.

CHE 6613. Technology of Fine Particles 3-0-3. Prerequisite: CHE 3311 or consent of School.
An examination of the properties of finely divided materials. Size, surface, pores are treated in relation to reactivity, absorptivity, catalytic behavior, and process engineering operations.
Text: at the level of Allen, Particle Size Measurement.

CHE 6618. Chemical Engineering Thermodynamics I 3-0-3. Prerequisite: CHE 3311 or consent of School.
Advanced theory and applications of energy transport.
Text: at the level of Bird, Stewart, and Lightfoot, Transport Phenomena.

CHE 6619. Chemical Engineering Calculations I 3-0-3. Prerequisite: CHE 3313, MATH 2308.
A study of the application of classical mathematical methods (including Laplace transforms and Bessel functions) to the solution of simple chemical engineering problems.

CHE 6620. Chemical Engineering Calculations II 3-0-3. Prerequisite: CHE 6619 or consent of School.
A study of the application of modern mathematical techniques (including numerical methods and optimization procedures) to the solution of typical chemical engineering problems.

CHE 6622. Advanced Reactor Design 3-0-3. Prerequisite: CHE 4415.
A study of chemical kinetics and mechanisms in complex homogeneous and heterogeneous reaction systems. Design of chemical reactors for such systems.
Text: at the level of Smith, Chemical Engineering Kinetics.

CHE 6628. Advanced Unit Operations I 3-0-3. Prerequisite: CHE 3313.
Flow through conduits, metering of fluids, mixing of liquids, flow and heat transfer in heat exchangers, packed columns, and fluidized beds.

CHE 6629. Advanced Unit Operations II 3-0-3. Prerequisite: CHE 3313.
Thermal radiation in furnaces, measurement of elevated temperatures, condensation of mixed vapors and evaporation.
Text: at the level of Hotel, Radiative Transfer.

CHE 6635. Advanced Unit Operations III 3-0-3. Prerequisite: CHE 3313.
Vapor-liquid equilibrium and separation by distillation of binary and multicomponent mixtures. Factors influencing design and performance of fractionating equipment. Application of azetric and extractive distillation.
Text: at the level of Robinson and Gilliland, Elements of Practical Distillation.

CHE 6637. Advanced Unit Operations IV 3-0-3. Prerequisite: CHE 3313 or consent of School.

CHE 6750. Polymer Structure and Physical Properties I 3-0-3. Prerequisite: consent of School.
Morphology and structure, linear and nonlinear viscoelasticity, anistropic mechanical properties, and yield and fracture behavior of polymers with applications to textile fibers and plastic products. Also taught as CHE 6750.
Text: at the level of Ward, Mechanical Properties of Solid Polymers.

CHE 6751. Polymer Structure and Physical Properties II 3-0-3. Prerequisite: consent of School.
Structure-property relationships of elastomers, reinforced plastics, fibers, foams, and natural polymers with emphasis on proteins and the composite nature of all polymers and polymer products. Also taught as TEX 6751.
Text: at the level of Ward, Mechanical Properties of Solid Polymers.

CHE 6753. Surface Science and Technology Laboratory 3-18-9. Prerequisite: consent of School.
A highly specialized laboratory course using modern analytical and research instrumentation to characterize and study the surface properties of materials. Also taught as CHEM 6753 and PHYS 6753.

CHE 6754. Electrochemistry 3-0-3. Prerequisite: consent of School.
A study of electrochemical instrumentation; the thermodynamics, structure, absorption of the electrical double layer, and the kinetics of simple and complex electrolyte processes. Also taught as CHEM 6754.

CHE 6775. Advanced Engineering Programming Methods 3-3-4. Prerequisite: FORTRAN programming knowledge.
Advanced engineering programming concepts and their implementation on large-scale digital computers, dynamic data, dynamic programs, engineering data management, primary memory management, engineering problem-oriented language development, and ICES. Also taught as CE 6775 and NE 6775.

CHE 6787. Heterogeneous Catalysis 3-0-3. Prerequisite: CHE 6622 or consent of instructor.
Physics and chemistry of surfaces, thermodynamics, kinetics and mechanism of chemisorption and surface reactions; industrial catalysts. Also taught as MET 6787.
Text: at the level of Satterfield, Heterogeneous Catalysis in Practice.

CHE 7000. Master's Thesis Credit to be arranged.

CHE 7750. Surface and Solution Properties of Polymers 3-0-3. Prerequisite: consent of School.
Study of plasticized polymers, solutions, and colloids; sorption, polymer characterization; interfacial phenomena, and coagulation using thermodynamics, statistical mechanics, information, and fluctuation theories and relaxation methods. Also taught as TEX 7750.
**School of Civil Engineering**

*Established in 1896*


**General Information**

The School of Civil Engineering offers courses in civil engineering and engineering graphics and programs leading to the degrees Bachelor of Civil Engineering, Bachelor of Science (undesignated), Master of Science in Civil Engineering, Master of Science in Environmental Engineering, Master of Science (undesignated), and Doctor of Philosophy. Also offered is a joint two-year program leading to the degrees Master of Science in Civil Engineering or Master of Science (undesignated), major in transportation engineering, and Master of City Planning.

**Multidisciplinary Programs**

See table on page 78.

**Program in Engineering Graphics**

The School of Civil Engineering offers EGR 1170, Introduction to Visual Communication and Engineering Design. Many engineering curricula require this course; other engineering and non-engineering curricula accept engineering graphics as an elective.

The objective of the course is to teach the student the principles of graphic expression. Thus, the student should schedule this course during the freshman year, so that principles learned therein may be used in later engineering courses.

**Bachelor of Civil Engineering**

The four-year curriculum leading to the degree Bachelor of Civil Engineering enables the graduate to enter professional practice as an engineer or to continue his or her studies in programs leading to advanced degrees in the following broad fields of specialization: construction management, environmental engineering, fluid mechanics, hydraulics, hydrology, materials, soil mechanics, structures, transportation, and water resources planning and management. The graduate of the B.C.E. curriculum may function in the areas of planning and design, construction, research and development, operations, and maintenance. Since the inauguration of its accrediting program in 1936-1938, the Accreditation Board for Engineering and Technology has continuously accredited the curriculum leading to the Bachelor of Civil Engineering degree. Graduates of the B.C.E. curriculum are eligible to seek licensing as registered professional engineers.

The course requirements of the Bachelor of Civil Engineering degree are listed here. Although students do not have to take the courses during the quarter indicated, they must satisfy all prerequisites for a particular course.

In addition to campus-wide academic requirements for graduation with a bachelor's degree, the following are also required for the B.C.E. degree.

(a) The scholastic average shall be a minimum of 2.0 for those quarters during which the student takes the last fifty-four hours toward the degree.

(b) The number of quality points earned in civil engineering courses taken toward the degree must be at least twice the number of credit hours in those courses.

(c) No more than twelve hours of free electives may be taken on a pass/fail basis. No other courses may be taken on a pass/fail basis.

Students who complete both the bachelor's and master's degrees in the School of Civil Engineering may use up to nine credit hours of graduate level course work (as approved by the Civil Engineering School) in the major discipline for both degrees. In order to qualify for this option, the student must complete the undergraduate degree with a cumulative grade point average of 3.3 or higher and complete the master's degree within two years after the award date of the bachelor's degree.

**Curriculum**

**Freshman Year**

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| CE 1500                 | 2-3-3  |        |        |
| ENGL 1901-2            | 3-0-3  | 3-0-3  |        |
| Electives              | 6-0-6  |        |        |

**Civil Engineering**
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**Master of Science**

The School of Civil Engineering awards three degrees in this category: Master of Science in Civil Engineering, Master of Science in Environmental Engineering, and the undesignated Master of Science. Common requirements for these degrees, in addition to those specified in the section "Information for Graduate Students," are listed below.

1. A minimum of fifty hours of course work, none of which was used to satisfy requirements for a previous degree, is required with the approval of the student's adviser and the director (see exceptions below).

2. Up to fifteen of the fifty hours can be in 3000-4000 level courses. Courses required for the B.C.E. degree cannot be used to satisfy this requirement; other 3000-4000 level courses may be used with the approval of the adviser and director (see exceptions below).

3. Up to six of the fifty hours may be taken on a pass/fail basis with the approval of the adviser and director.

4. Each M.S. student must either (a) write an M.S. thesis and schedule at least seventeen hours of CE 7000 or (b) write an M.S. special research problem and schedule at least six and twelve hours of CE 8756. No more than seventeen hours of CE 7000, nor more than twelve hours of CE 8756, may count as part of the fifty hours required for the M.S. degree.

5. Students electing to write an M.S. thesis must take at least eighteen hours of coursework in their major field. Students electing to write an M.S. special research problem must take at least twenty-seven hours of course work (including CE 8756) in their major field. Only those students who have previously earned the B.C.E. or its equivalent may receive the Master of Science in Civil Engineering. The School awards the Master of Science in Environmental Engineering only to those students who have previously earned the B.C.E. or who have earned an accredited bachelor's degree in engineering and taken those undergraduate courses (for no credit toward the M.S.) required by their adviser and the director. Students who do not meet the above requirements but satisfy all prerequisites for the courses in their M.S. program receive the undesignated Master of Science degree.

A wide range of M.S. programs is available in fields such as construction management, environmental engineering, fluid mechanics, hydraulics, hydrology, soil mechanics, materials, structures, transportation, and water resources planning and management. The School encourages latitude in the selection of courses in an M.S. program, provided that the resulting program leads to a definable goal.

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1. See College of Engineering section "Curricula and Courses of Instruction" for engineering electives that can be substituted for CE 1503.
2. These free elective courses may be taken at any time during a student's course of study. Physical education courses may not be used to satisfy this requirement.
3. See "Curricula and Courses of Instruction," Department of Physical Education and Recreation, for physical education requirements.
4. Six hours of free electives at the 3000 level or higher, excluding Physical Education, must be taken if advanced ROTC is not taken.
5. CE Electives. Nine hours chosen from 4000-level CE courses, not otherwise required in the B.C.E curriculum, or graduate level CE courses as approved by adviser and director (minimum of 2.7 average required for an undergraduate to take a graduate course).
6. See "Information for Undergraduate Students" section of this catalog for humanities, social science, and modern language requirements.
7. CHEM 1102 is prerequisite for CHEM 2113, recommended for specialization in Environmental Engineering. PHYS 2123 is corequisite for ME 3720.
The degree Master of Science in Environmental Engineering is accredited by the Accreditation Board for Engineering and Technology. The undesignated Master of Science is not an engineering degree; holders of this degree may not be licensed as professional engineers unless they have an ABET accredited bachelor's degree in engineering.

Students who complete both the bachelor's and master's degrees in the School of Civil Engineering may use up to nine credit hours of graduate-level course work (as approved by the CE School) in the major discipline for both degrees. In order to qualify for this option, the student must complete the undergraduate degree with a cumulative grade point average of 3.3 or higher and complete the master's degree within two years after the award date of the bachelor's degree.

Graduates of technology programs are not directly admissible to graduate study in the School of Civil Engineering. Non-citizens seeking admission to graduate study are required to submit a minimum TOEFL score of 550 or to have been in residence at a U.S. university for a full academic year.

The Ph.D. is the highest degree awarded and as such requires the highest level of proficiency and achievement, both in knowledge and in the performance of research presented in a written dissertation. While there are no specific course requirements, most doctoral students spend approximately two years in course work beyond the bachelor's degree while conducting their research activities, plus at least another year on full-time research. There is no longer a Ph.D. language requirement.

Courses of Instruction

CIVIL ENGINEERING

CE 1503. Introduction to Civil Engineering 2-3-3. Not offered summer quarter.

- What engineering is, what civil engineering is, and what civil engineers do. The civil engineering approach to the solution of mankind's problems.

CE 2264. Plane Surveying 3-3-4. Prerequisite: EGR 1700. Use of modern instruments and office procedures to obtain and analyze field data for use in engineering planning, design, and construction. Introduction to photogrammetry.

CE 3053. Fluid Mechanics I 3-0-3. Prerequisite: ESM 3201. Elementary mechanics of fluids with emphasis on analysis, fluid kinematics, equations of motion, momentum and energy principles, surface and form resistance.

CE 3054. Fluid Mechanics II 3-3-4. Prerequisite: CE 3053. Elementary mechanics of fluids with emphasis on engineering applications. Enclosed conduit flow, open-channel flow, hydraulic machinery, fluid measurements, dynamic similarity.

CE 3061. Fluid Mechanics Laboratory 0-3-1. Prerequisite: CE 3054. Experiment, demonstration, and analysis of basic fluid phenomena and exercises in laboratory techniques.

CE 3224. Structural Analysis I 3-3-4. Prerequisite: ESM 3201. Determination of internal forces and deflections in statically determinate trusses, beams, and frames. Introduction to analysis of statically indeterminate structures and to formulation of influence lines.

CE 3254. Advanced Surveying I 3-3-4. Prerequisite: CE 2254. Not offered winter quarter.

- Field astronomy. Precise taping, leveling, triangulation, sub-grade bar, adjustments of level nets and triangulation figures, special problems in land division, introduction to photogrammetry.

CE 3309. Materials of Construction 3-3-4. Prerequisites: ESM 3301, GEOL 2100, 2102. Basic principles of the properties of materials. Physical, chemical, and mechanical properties of metals, concrete, timber, masonry, and asphalt. The laboratory period is for tests, demonstrations, and writing reports.

CE 3513. C.E. Applications of Digital Computers 3-0-3. Prerequisite: MATH 1308. The application of digital computers to the solution of civil engineering problems using FORTRAN. This course is prerequisite to all CE courses shown in CE curriculum after first quarter, junior year.

CE 3534. Stochastic Methods and Applications in Civil Engineering 3-3-4. Prerequisite: MATH 2308. Identification and modeling of non-deterministic problems in civil engineering and treatment thereof relative to engineering design and decision making. Probability and simulation models in the various areas of civil engineering.

CE 4003. Construction 2-3-3. Prerequisite: ISYE 4725.

- The construction industry, contracts, and forms of construction company organization. Financing, equipment, manpower, and materials. Time and cost control methods are introduced.

CE 4013. Design of Construction Operations 3-0-3. Prerequisite: junior standing. Modeling and analysis of construction operations at the job site level. Productivity calculations and allocation of construction resources.


CE 4108. Environmental Engineering I 3-0-3. Prerequisites: MATH 2308, CHEM 1101. Introduction to physical, chemical, and biological properties of the aquatic environment with reference to environmental quality. Quality of water for domestic use. Basic principles of aquatic microbiology and chemistry.


CE 4128. Environmental Engineering III 2-3-3. Prerequisite: CE 4118. The layout, hydraulic process, and operational design of water and waste water systems. Supervised design problems and inspection trips.

CE 4133. Engineering Aspects of Environmental Health 3-0-3. Prerequisite: CE 4118. Sanitary engineering in public health administration and control of environmental health problems.


CE 4142. Environmental Microbiology Laboratory 1-3-2. Corequisite: CE 4148. Basic laboratory exercises and discussions for the understanding of fundamental and applied microbiological principles in environmental engineering.
Curricula and Courses of Instruction

CE 4313. Transportation Engineering II 3-0-3. Prerequisite: senior standing. History and economics of transportation systems, traffic and planning problems and techniques, planning and design of air, rail, highway, and water transportation facilities as a system.

CE 4353. Hydrology 3-0-3. Prerequisite: CE 3054. Occurrence and movement of water of the earth, hydrologic measurements, elementary meteorology, precipitation, evapotranspiration and runoff, ground water, frequency analysis.


CE 4383. Groundwater Hydrology 3-0-3. Prerequisites: CE 4353, GEOL 2100. Spring quarter. Occurrence, distribution, and movement of water below the surface of the earth, groundwater resources, and dependable supplies from wells, artificial recharge, and waste disposal.

CE 4801-2-3-4-5-6. Special Topics Credit hours equal last digit of course number.

CE 4811-2-3-23. Special Topics Credit hours equal last digit of course number.

CE 4900. Special Problems. Credit hours to be arranged.


CE 6023. Civil Engineering Management II 2-3-3. Prerequisite: CE 6013. Corequisite: ISYE 6734. Spring quarter. Continuation of CE 6013. Additional topics include linear and dynamic programming, queueing models and simulation as applied to construction project management.

CE 6051. Intermediate Fluid Mechanics I 3-0-3. Prerequisite: CE 3054. Fall quarter. Basic analytical techniques of fluid mechanics; kinematics and dynamics of fluid flows; conservation of mass, momentum, and energy; Bernoulli and Navier-Stokes equations; potential flow.


CE 6062. Environmental Fluid Mechanics II 2-3-3. Prerequisite: CE 6061. Summer quarter. Practical application of basic principles to engineering situations. Mixing in rivers, lakes, reservoirs, estuaries; the use of numerical and physical models.


CE 6084. Transient Flow in Enclosed Conduits 2-3-3. Prerequisite: CE 3054. Spring quarter. Unsteady flow of compressible and incompressible fluids in conduits, pressure wave propagation, one-dimensional wave equations, method of characteristics, pulsating flow, water hammer, hydraulic machinery, column separation.

CE 6086. Sediment Transport 3-0-3. Prerequisite: CE 3054. Fall quarter. Sediment transport, sediment motion by flow, bed load transport, boundary layer theory, bed load discharge, bed form mechanics, hydraulic resistance to flow, Reservoir sedimentation.


CE 6102. Physical Principles in Environmental Engineering 4-0-4. Fall quarter. Analysis of the physical principles of water quality control, such as sedimentation, flocculation, filtration, inertial separation, gas transfer, and principles of reactor design.


CE 6116. Environmental Engineering Processes Laboratory 1-3-3. Prerequisites: CE 6140, 6141, and 6142. Summer quarter. Laboratory evaluation of various physical-chemical and biological processes which form the basis of many water quality control operations including coagulation, thickening, adsorption, gas transfer, membrane separations, filtration, dewatering, and biological oxidation.


CE 6128. Solid Waste Technology II 2-3-3. Prerequisite: CE 6118. Spring quarter. Evaluation of typical solid waste problems, application of fundamental principles to design and management, case studies of operational solid waste systems, new methods, advanced topics.

CE 6130. Environmental Processes in Surface Water Systems 3-0-3. Prerequisite: CE 4118. Winter quarter. Analysis of chemical, physical, and biological processes occurring in natural water systems such as streams, lakes, and estuaries.

CE 6136. Applications of Chemistry in Environmental Engineering 3-0-3. Prerequisite: CE 6136. Fall quarter. Kinetic and equilibrium relationships controlling the chemical behavior of the aquatic environment. Distribution of chemical species in dilute aqueous systems.

CE 6138. Applied Limnology
2-3-3. Spring quarter.
Consideration and application of limnological principles as they pertain to evaluating the impact waste water disposal will have on the biological productivity of inland waters.

CE 6140. Environmental Engineering Processes I
4-0-4. Prerequisites: CE 3054, CE 4118, CE 6102, and CE 6136. Winter quarter.
Theory and application of the physical and chemical processes of coagulation, flocculation, sedimentation, and filtration in water and waste water treatment.

CE 6141. Environmental Engineering Processes II
4-0-4. Prerequisites: CE 4118, CE 4148, CE 6102, and CE 6136. Winter quarter.
Study of biological and chemical processes employed in water and waste water treatment systems. Biological growth kinetics, biological reactor configuration including activated sludge, trickling filters, lagoons, and oxidation ponds.

CE 6142. Environmental Engineering Processes III
3-0-3. Prerequisite: CE 6102. Spring quarter.
Advanced treatment processes in environmental engineering including membrane separation, adsorption, and ion exchange.

CE 6146. Field Methods in Environmental Engineering
0-15-5. Summer quarter.
Organization and conduct of water quality surveys and field studies for natural waters.

CE 6148. Advanced Microbiology of Water and Wastes
2-3-3. Prerequisite: CE 4148. Winter quarter.
Microbial growth in water and waste treatment systems, enrichment cultures, and their application in process design. Respiratory mechanisms and fermentations in waste treatment and stream pollution.

CE 6153. Dock, Harbor, and Shore Structures
3-0-3. Prerequisite: CE 4214. Spring quarter.
Function, design, and construction of marine structures such as docks, bulkheads, dry docks, breakwaters, channels, and shore protection works.

CE 6154. Advanced Soil Mechanics
3-2-4. Prerequisite: CE 4163. Winter quarter.
Flow of water through soil, rock, design of drainage systems, earth dams, and dam foundations. Elastic and plastic equilibrium applied to problems of slope stability.

CE 6159. Rock Mechanics
3-3-4. Prerequisite: CE 4163. Spring quarter.
Mechanics of rock masses and influence of geologic features on their engineering properties. Discussion of relevant tests for determination of both in situ and laboratory properties of rocks.

CE 6163. Physical and Physicochemical Properties of Soils
3-0-3. Prerequisite: CE 4154. Fall quarter.
Formation of soils, physical chemistry of soil minerals and soil water, consolidation, swell, shrinkage, shear strength and related phenomena, geology of soil deposits.

CE 6164. Advanced Foundation Engineering
3-3-4. Prerequisite: CE 4163. Spring quarter.
Analysis and design of foundations, bearing capacity and settlement theory. Analysis of pile and continuous foundations, theories of earth pressure, design of earth retaining structures.

CE 6172. Soil Testing
1-3-2. Prerequisite: CE 6194. Winter quarter.
Theory of physical testing of soils for engineering design and research, laboratory exercises in consolidation and shear testing, illustrations of test procedures, effects on character of data.

CE 6173. Terrain Evaluation and Applications
2-3-3. Prerequisite: CE 4163. Fall quarter.
Structure of soil and rock formations and their reflection in the terrain. Analysis of terrain features by aerial photographs and other forms of remote sensing.

CE 6183. Soil Construction
2-3-3. Corequisite: CE 4154. Fall quarter.
The migration of soil moisture, frost action, compaction, soil stabilization, evaluation of subgrades and bases for pavements.

CE 6184. Soil Stabilization and Site Improvement
3-0-3. Prerequisite: CE 4163. Spring quarter.
Mechanical, chemical, and reinforcing methods for improving the engineering properties of soil used as a construction material or used to support foundations.

CE 6193. Dynamics of Massive Media
2-3-3. Summer quarter.
Introduction to dynamics of massive media with applications to analysis of vibratory machine foundations and earthquake problems including slope stability and liquefaction. Dynamic properties of soil and rock.

CE 6194. Theoretical and Applied Soil Mechanics I
4-0-4. Corequisite: CE 6163. Fall quarter.
Theories of elastic equilibrium of soil masses. Application to analysis of complex soil engineering problems such as stresses and settlements of soil, mat foundations, laterally loaded piles, and pile groups.

CE 6199. Theoretical and Applied Soil Mechanics II
4-0-0. Prerequisite: CE 6194. Winter quarter.
Theories of plastic equilibrium of soil masses, application to analysis of complex soil engineering problems. Pressures on earth retaining structures, anchored bulkheads, laterally loaded piles, and earth anchors.

CE 6203. Structural Planning
3-0-3. Prerequisite: CE 3224. Spring and summer quarters.
Introduction to planning aspects of structural design, economic proportions, erection procedures, comparison of determinate and indeterminate structures, stress control, normal and hybrid behavior.

CE 6204. Reinforced Concrete Structures I
4-0-4. Prerequisite: CE 4214. Fall quarter.
Review of working stress methods, analysis and design procedures based on ultimate load capacity, effects of creep, shrinkage, and temperature, torsional stresses and reinforcing, deflections.

CE 6209. Reinforced Concrete Structures II
4-0-4. Prerequisite: CE 6204. Winter quarter.
Principles and practice of prestressed concrete, systems and techniques for applying prestress, analysis and design of determinate and indeterminate prestressed concrete structures, ultimate strength behavior.

CE 6213. Experimental Analysis I
3-0-3. Winter quarter.
Data acquisition from models. Stress analysis through strain measurements. Transducers, their circuitry and related indicating and recording equipment. Motion measurement, equivalent circuits.

CE 6214. Indeterminate Structural Theory I
4-0-4. Prerequisite: CE 3224. Fall quarter.
Study of principles and fundamental theorems of structural analysis with applications to indeterminate structures: beams, frames, and trusses.

CE 6219. Matrix Methods of Structural Dynamics
4-0-4. Prerequisites: CE 6229, CE 6248. Winter quarter.

CE 6229. Principles of Matrix Structural Analysis
4-0-0. Prerequisite: CE 3224. Fall quarter.
Matrix formulation of the governing equations of framed structures, linear elastic behavior, physical and geometrical nonlinearities, force and displacement methods, nonlinear analysis.

CE 6234. Advanced Structural Mechanics
4-0-4. Prerequisite: MATH 2308. Winter quarter.
Study of advanced topics from mechanics of materials with application to civil engineering structures. Typical topics: generalized stress and strain, failure theories, torsion, shear flow, buckling, fatigue.

CE 6238. Finite Element Method of Structural Analysis
3-0-3. Prerequisite: CE 6229. Spring quarter.
Introduction to finite element method, matrix formulation. Plates in plane stress, plane strain and bending. Three-dimensional solids and shells. Static and dynamic, linear and nonlinear analysis.

CE 6244. Plastic Design in Steel
4-0-4. Prerequisite: CE 4204. Spring quarter.
Analysis and design procedures based on ultimate load capacity are applied to steel beams, frames, and their connections.

CE 6248. Structural Dynamics
3-0-3. Prerequisite: consent of School. Fall quarter.
Vibration and dynamic response of simple linear and nonlinear structures to periodic and general disturbing forces. Response analysis of multi-degree of freedom systems. Wind and earthquake effects.

CE 6249. Reinforced Concrete Structures III
4-0-4. Prerequisites: CE 6209, MATH 2308. Spring quarter.
Analysis and design of slab and thin-shell structures, additional applications of prestressing, yield-line theory, shells of revolution, cylindrical shells, folded plates, hyperbolic paraboloids, prestressed tanks.

CE 6250. Earthquake Engineering
3-0-3. Prerequisite: CE 6248. Summer quarter.
Analysis and design of civil engineering structures for earthquake resistance; building code requirements; case studies.

CE 6273. Legal Principles of Land Surveying
2-3-3. Prerequisite: CE 2264. Winter quarter, alternate years.
History and development of legal principles controlling boundary location of real property. Writing, interpreting, and locating deed descriptions.

CE 6303. Pavement Design
3-0-3. Prerequisites: CE 4304, 4154. Spring quarter.
Theory of flexible and rigid pavement behavior, stress condition and deflection, climate, pavement design methods, and evaluation of pavement performance.

CE 6305. Advanced Transportation Planning
2-3-3. Prerequisite: CE 6344. Examination of advanced methods and problems in transportation planning, land use models, the Urban Transportation Planning System (UTPS), and evaluation of transportation plans; computer modeling.

CE 6308. Concrete Technology
Design theories for concrete mixes, mixes for specific conditions of workability, density, strength, admixtures and air entrainment. Preparation and testing of concrete mixes, minor research in concrete.

CE 6313. Airport Planning and Design
2-3-3. Prerequisite: CE 4304. Fall quarter.
Airport site selection, runway length and orientation, traffic control, drainage and lighting, long-range planning, government responsibility for air transportation.

CE 6315. Computerized Traffic Surveillance and Control
3-0-3. Prerequisite: CE 6333.
Real time monitoring and control of traffic on streets and freeways. Detectorization, computer strategies and software, communications, signals, implementation. TRANSYT program for optimal signal timing.

CE 6318. Asphalt Technology
2-3-3. Prerequisite: CE 4313, 4154. Fall quarter.
CE 6333. Transportation Administration 2-3-3. Fall quarter.
Advanced study of national transportation policies, financial problems, administrative procedures relating to development of transportation facilities.

Characteristics and costs of present and innovative mass transit systems. Roles of engineer, planner, and others in estimating transit usage and choosing optimal plan.

CE 6333. Traffic Engineering 2-3-3. Prerequisite: CE 4304. Fall quarter.
Characteristics of drivers and vehicles, traffic studies, capacity, signal systems, engineering solution of traffic movement problems. Supervised traffic engineering studies.

Application of traffic control devices to improve capacity, safety of urban street systems. Emphasis on computer control of signal systems, application of computer simulation models.

Geometric constants of expressways, highways, railways, and their terminals to meet characteristics of vehicle performance and operator limitations.

CE 6344. Urban Transportation Planning 3-3-4. Prerequisite: CE 6333. Winter quarter.
Planning of urban transportation facilities. Mathematical models for prediction of traffic flow, assignment, interrelationships of land use and trips, parking and the transportation problem.

Discounting techniques for public works planning. Microeconomics in project formulation. Applications from public works economics, capital formation theory, input-output analysis.

Principles of resource allocation, benefit-cost analysis. Water-resources project formulation, justification, allocation of joint costs in multipurpose developments.

CE 6371. Statistical Hydrology 2-3-3. Prerequisite: consent of instructor. Winter quarter.
Probability distributions applicable to hydrologic events; analysis of extreme events, floods and droughts, characteristics of drivers and vehicles, traffic studies, capacity, signal systems, engineering solution of traffic movement problems. Supervised traffic engineering studies.

Stochastic modeling of hydrologic processes. Problems of model specification, parameter identification, and validation. Application to forecasting and synthetic events.

CE 6373. Flood Management 3-0-3. Prerequisite: CE 6371. Fall quarter.
Hydrology and hydraulics of flood management measures. Analysis of flood control and flood damage abatement: levees, floodways, channel improvements, reservoirs.

CE 6374. Physical Hydrology 3-0-3. Prerequisite: CE 4353. Fall quarter.
Study of physical processes governing occurrence, movement, and distribution of water; atmospheric transport processes and circulation; precipitation, evaporation, transpiration, snowmelt; infiltration; ground-water flow; and catchment morphology.

Development of deterministic watershed simulation models including surface runoff, overland flow, streamflow, flood routing, reservoir routing. Linear catchment models. Data preparation techniques for watershed models.

Characterization of existing deterministic watershed simulation models, model selection, calibration techniques, simulation techniques. Students will calibrate several representative models to measured data.

Effects of urbanization on storm runoff, sedimentation, water quality, and water supply. Modeling of urban runoff relationships in planning and design. Legal, institutional, and economic framework.

CE 6399. Water Resources Systems I 3-0-3. Prerequisite: ISYE 6734 or equivalent, or consent of instructor. Spring quarter.
Review and application of operations research methodologies, including classical optimization, linear programming, nonlinear programming and dynamic programming, to planning and design of water resource systems.

Outlines the extent of uncertainties under which civil engineering designs and decisions are made. Theory and application. First step toward developing a risk-based design format.


A study of system design using MSI and LSI chips, and programmable digital devices as system modules. Subjects include Boolean optimization and register transfer design techniques.

CE 6773. Computer Control of Real-Time Systems 3-3-4. Prerequisite: NE 6770, EE 4077 or equivalent. Summer quarter.
A study of concepts common to all computer controlled real-time systems. Subjects include evolution of time sets, vectorized interrupts, and statistical alarm conditions.

CE 6775. Advanced Engineering Programming Methods 3-3-4. Prerequisite: CE 3513 or equivalent. Summer quarter.
Advanced engineering programming concepts and their implementation on large scale digital computers. Dynamic data, dynamic programs, engineering data management, engineering problem oriented language development and ICES.

CE 7000. Master's Thesis Credit hours to be arranged.

CE 7999. Doctoral Examinations Preparation Credit hours to be arranged.
For students preparing for doctoral qualifying and language examinations or both.

CE 8002. Seminar in Environmental Engineering 0-2-1. Developments in environmental engineering science and technology, current research, and special topics related to environmental quality assurance and control.

CE 8003. Research Seminar in Environmental Engineering 0-1-1. Prerequisites: CE 4148, CE 6346, and graduate status.
Discussions of current research topics in environmental engineering. Emphasis on critical in-depth review of published research results and those presented by doctoral students.

Case histories of design and construction problems involving soil and rock mechanics, including excavations, drainage, dams, retaining structures, and slope stability.

Case histories of design, construction, and performance of foundations. Special topics such as machine foundations, foundations in seismic regions.

CE 8051. Seminar in Transportation Engineering 0-2-1. Prerequisite: consent of School. Winter quarter.
Developments in the design and planning of traffic engineering and transportation systems, impact of current literature and technology on the field.

School of Electrical Engineering
Established in 1896

Director and Professor—Demetrios T. Paris; Associate Director and Professor—Roger P. Webb (Georgia Power Chair); Assistant Director for Graduate Affairs and Professor—Dale C. Ray; Assistant Director for Undergraduate Affairs and Professor—Thomas M. White, Jr.; Assistant to the Director for Laboratory Instruction—Thomas E. Brewer; Regents' Professors—John W. Hooper, George P. Rodrigue, Ronald W.

General Information

Electrical engineers have pioneered the fields of electronics, computers, control, power, and communication. Their work is vital in almost every sector of society. The tremendous effect of electrical engineering on society can be explained by the fact that electrical energy is the only known form of energy that can be transmitted efficiently under controlled conditions, even through a vacuum, and by means of which intelligence can be processed and transferred effectively even over extremely long distances.

The School of Electrical Engineering seeks to attract students who possess a verbal and written command of the English language; exhibit logical thinking, creativity, curiosity, imagination, persistence, and patience; and demonstrate a mastery of mathematics, chemistry, and physics.

At the undergraduate level, a broad range of electives balances the basic required program of instruction in fundamental theory and laboratory practice. These electives are available in a wide variety of major areas such as audio engineering, integrated circuits and systems, digital signal processing, fiber optics, applied electromagnetics, communications, computer engineering, solid-state electronics, and energy engineering. The student, with the counsel and guidance of faculty advisers, designs an electives program around his or her own special interests.

The graduate programs leading to the master's and doctoral degrees provide a broad education covering more than one specialty, followed by in-depth studies of major and minor interest areas. The doctoral program requires, in addition, concentration in a single specialty or in a group of closely related specialties.

Graduate programs include computer engineering, digital signal processing, electronic power engineering, electromagnetics, microelectronics, modern electronics, modern optics, systems and controls, and telecommunications. Multidisciplinary non-degree programs in areas such as computer engineering and acoustic engineering are offered jointly with other engineering schools on campus. Full programs of courses are offered during the summer quarter, making it possible for part-time students to continue an uninterrupted program of study throughout the year. Full-time students can complete their master's program in one calendar year.

Housed in a modern facility, the School maintains a vigorous program of student-centered research conducted in well-equipped laboratories.

Additional information about the programs may be obtained from the School's Student Handbook, available upon request or by calling the School at (404)894-2900. Every student enrolled must consult this source of information with respect to special rules and degree requirements.

Certificate Program in Computer Engineering

Computers have become an integral part of today's society and are now used in all facets of society including scientific research, industry, business, commerce, and even in the home with calculators and computer controlled appliances. With this increasing use comes an increasing demand for people who understand the design, construction, operation, and application of computers. To satisfy this demand, the School has developed programs in computer engineering.

Computer engineering in the School of Electrical Engineering encompasses both traditional areas of computer engineering—the engineering of computers and engineering with computers. Engineering of computers emphasizes the design of computers and requires expertise in computational theory, digital design, and computer architecture. Engineering with computers emphasizes the use of computers in engineering systems and requires computer interfacing techniques, both low-level and high-level programming techniques, and a general knowledge of computer operating systems. Both areas require an in-depth understanding of computer software at the elementary and systems level. Hence, computer engineering encompasses all aspects of design, theory, and practice relating to systems for digital and analog computation and information processing; components and circuits for computing systems; relevant portions of supporting disciplines; production, testing, operation, and reliability of computing systems; applications, use, and programming of computing devices and information processing systems; and the use of computers in electrical and electronic engineering.

Those undergraduate engineering students who specialize in the area of Computer Engineering receive a Certificate in Computer Engineering. To qualify for this certificate, a student must complete all requirements for an ABET-accredited bachelor's degree in an engineering discipline and, in addition, must successfully complete, with a grade of C or better, the following nine elective courses, totaling thirty quarter hours: EE 1010, EE 3032, EE 3033, EE 3034, EE 4075, EE 4077, EE 4080, ICS 2100, and MATH 2012. None of these courses may be specifically required by title and number for the bachelor's degree in the student's major field. Non-electrical engineering students may substitute EE 3360 for one of the EE courses listed in the program.

Interested students may obtain further information by directly contacting the School of Electrical Engineering.

Multidisciplinary Programs

See table on page 78.

Curriculum

Freshman Year
Course 1st Q. 2nd Q. 3rd Q.

Elective 1  3-0-3

Electives 2 Science/Modern Language 3-0-3 3-0-3

ENGL 1001-2 3-0-3 3-0-3

Elective Any one of the freshman engineering electives 3 X-X-X

MATH 1307-8-9 Calculus I, II, III 5-0-5 5-0-5 5-0-5

PHYS 2111 Particle Dynamics 4-3-5

CHEM 1101-2 General Chemistry 4-3-5 4-3-5

Electives 3 Physical Education X-X-2 X-X-1 X-X-1

Totals X-X-18 X-X-17 X-X-17

Curricula and Courses of Instruction
Sophomore Year

Course | 1st Q. | 2nd Q. | 3rd Q. |
--- | --- | --- | --- |
Elective<sup>1</sup> | 3-0-3 | | |
Elective<sup>2</sup> | | | |
Humanities/Social Science/Modern Language | 3-0-3 | 3-0-3 | |
ESMT 2201 Statics | 3-0-3 | | |
ESMT 3201 Dynamics I | | 3-0-3 | |
MATH 2307 Calculus IV | 5-0-5 | | |
MATH 2308 Calculus V | | 5-0-5 | |
MATH 3308 Differential Equations | | 5-0-5 | |
PHYS 2122 Electromagnetism | 4-3-5 | | |
PHYS 2123 Optics and Modern Physics | 4-3-5 | | |

<sup>1</sup>Electives: The electrical engineering curriculum contains fifty-seven hours of electives, in addition to four hours of specified physical education electives and thirty hours of specified humanities/social science, science, and modern language electives. The fifty-seven hours of electives shall include a minimum of:

Three hours of freshman engineering electives. See “Curricula and Courses of Instruction,” College of Engineering.

Three hours of junior-level or senior-level course work in written or verbal communication, with emphasis on ideas which may be one of the following English courses: ENGL 3015, ENGL 3020, ENGL 3024.

Twelve hours of technical electives subject to school approval. Generally, the technical electives are senior engineering (not EE), mathematics, or natural science courses. These electives must include one of the following engineering options: (1) ME 3720, ME 3726, ME 3727, (2) ENGR 3723, and (3) PHYS 3723 (4) PHYS 3724, (5) a course or courses approved by the School of Electrical Engineering. In addition, one course in graphics is strongly recommended.

Eighteen hours of electrical engineering electives subject to school approval. Three hours (minimum) of applied probability selected from (1) EE 3340, (2) PHYS 3145, (3) ISE 3027, (4) BIOL 3333, (5) MATH 3710, (6) MATH 3215, (7) MATH 4215. EE 3340 will apply toward satisfying the EE elective course requirements; all other courses will apply toward satisfying the technical breadth requirement for the bachelor’s degree in electrical engineering.

EE 3200-50 Elements of Electrical Engineering<sup>3</sup> | 3-0-3 | 3-0-3 | |
EE 3400 Instrumentation Laboratory | | 1-3-2 | |
EE 3360 Digital Hardware | | 3-0-3 | |
EE 3411 Junior EE Laboratory I | | 0-3-1 | |
Totals | 18-3-19 | 15-3-16 | 15-6-17 |

Junior Year

Course | 1st Q. | 2nd Q. | 3rd Q. |
--- | --- | --- | --- |
Electives<sup>4</sup> | 4-0-4 | 4-0-4 | 4-0-4 |
Electives<sup>5</sup> | | | |
Humanities/Social Science/Modern Language | 3-0-3 | 3-0-3 | 3-0-3 |
EE 3360 Digital Hardware | 3-0-3 | 3-0-3 | 3-0-3 |
EE 3120-20 Circuits and Systems | 3-0-3 | | |
EE 3210-20 Circuits and Systems | | 3-0-3 | |
EE 3215 Signals and Systems | | | 3-0-3 |
EE 3260 Engineering Electronics | | | 3-0-3 |
EE 3270 Nonlinear Devices and Circuits | | | 3-0-3 |
EE 3330 Electro-Mechanical Systems and Energy Conversion | | | 3-0-3 |
EE 3421-31 Junior EE Laboratory II, III | | 0-3-1 | 0-3-1 |
Totals | 16-0-16 | 16-3-17 | 16-3-17 |

Senior Year

Course | 1st Q. | 2nd Q. | 3rd Q. |
--- | --- | --- | --- |
Electives<sup>6</sup> | 10-0-10 | 13-0-13 | 13-0-13 |
Electives<sup>7</sup> | | | |
Humanities/Social Science/Modern Language | 3-0-3 | 3-0-3 | 3-0-3 |
EE 4350 Materials Science | 3-0-3 | | |
EE 4111-21 Senior EE Laboratory I, II | 0-3-1 | 0-3-1 | |
EE 4430 Project Laboratory | | | 0-3-1 |
Totals | 16-3-17 | 16-3-17 | 16-3-17 |

Courses of Instruction

EE 1001. Introduction to Electrical Engineering 1-0-1. Enrollment limited to freshmen. An introduction to electrical engineering, both at Georgia Tech and in industry; Lectures, discussion, and outside work provide insight to the exciting directions the profession is taking.

EE 1010. Computer Programming and Graphics 1-3-3. Computer programming and graphics using a problem solving approach. Programs are written in FORTRAN for the main campus computer (CDC Cyber 77) and a CALCOMP PLOTTER.


EE 1750. Introduction to Bioengineering 3-0-3.

An introduction to aspects of science and technology pertinent to bioengineering, with emphasis on ongoing activity at Georgia Tech.

EE 1900-2-3. Special Problems Credit to be arranged. Normally taken by freshmen. Special engineering problems are assigned according to each student's needs, interests, and capabilities.

EE 2900-1-2-3, Special Problems Credit to be arranged. Normally taken by sophomores. Special engineering problems are assigned according to each student's needs, interests, and capabilities.

EE 3015. Mechanical Plant of Buildings 3-0-3. Prerequisite: EE 3200, 3360, 3725.

Electrical power distribution systems for buildings and plants. Study of National Electrical Code. Lighting design considering sources, luminaires, and reflectances.


EE 3032. Computer Engineering I 3-0-3. Prerequisite: EE 1010, 3360.

Machine language, machine organization, and design concepts of digital computers. Loaders, assemblers, subroutines, recursive, and reentrant programs; Input, output, data structures, and arithmetic logic units.

Text: 8080/8085 Assembly Language Programming, Intel Corp.

EE 3033. Computer Engineering II 3-3-4. Prerequisite: EE 3032.

Register transfer level design of computer structures, including sequences for instruction fetch, arithmetic/ logic unit operations, microoperations, and timing and control. Discussion of bus structures, interrupts, and input/output. Design projects based on CDP implementations.

EE 3034. Computer Engineering III 3-0-3. Prerequisite: EE 3032.

A study of computational algorithms for computers and their implementation via hardware and software. Topics include: fixed point, BCD, and point operations, special functions, residue arithmetic, and multivalued logic.

Text: Hwang, Computer Arithmetic.

EE 3036. Computational Methods for Simulation 1-3-3. Prerequisite: MATH 3200 or 3308.

A study of numerical algorithms for solving complex electrical engineering problems using digital computers. Theoretical approaches and practical algorithms are discussed.

EE 3042. Electrical Measurements 3-3-4. Prerequisite: EE 3270, 3360, 3421.

A study of measurement of electrical quantities using electromechanical and electronic, analog, and digital methods, consideration of recording, indication and processing of measurement data.

Text: Cooper, Electronic Instrumentation and Measurement Techniques.

Curricula and Courses of Instruction

Electrical Engineering
Transmission lines and waveguides. Wire and aperture antennas. Arrays - Quasistatics.


EE 3330. Electromechanical Systems and Energy Conversion
3-0-3. Prerequisites: EE 3310, 3210.

Fundamentals of electromechanical energy conversion, electromechanical devices and systems. Energy state function, force energy relationships, basic transducers, introduction to A.C. and D.C. machines.


EE 3340. Random Signals and Noise
3-0-3. Prerequisite: EE 3215.

Study of probability, random variables, and random processes for applications in electrical engineering.

Text: Cover and McGillem, Probabilistic Methods of Signal Analysis.

EE 3360. Digital Hardware
3-0-3. Corequisite: EE 3411.

A study of gates, flip-flops, counters, registers, memory devices, and integrated circuits. Consideration of the architecture of computers and digital systems.

Text: Greenfield, Practical Digital Design Using IC's.

EE 3400. Instrumental Laboratory
1-3-2. Prerequisite: EE 3200. Corequisite: EE 3250 (for electrical engineering students) or EE 3701 (for non-electrical engineering students).

Development of concepts in modeling terminal characteristics of electronic devices and techniques for analyzing electronic circuits.


EE 3260. Engineering Electronics
3-0-3. Prerequisite: EE 3250.

Development of techniques necessary for the analysis of active linear electronic circuits.

Text: Sedra and Smith, Microelectronic Circuits.

EE 3270. Nonlinear Devices and Circuits
3-0-3. Prerequisite: EE 3250.


EE 3411. Junior Electrical Engineering Laboratory I
0-3-1. Corequisite: EE 3360.

Exercises in combinational and sequential design and hardware implementation utilizing TTL, gates, flip-flops, multiplexers, and counters.

Text: Wallace, Digital Hardware Laboratory Experiments.

EE 3421. Junior Electrical Engineering Laboratory II
3-0-1. Prerequisite: EE 3330. Corequisite: EE 3270 (for electrical engineering students) or EE 3702 (for non-electrical engineering students).

Experiments in linear circuits and electronics with emphasis on the relationship between circuit models and their physical realization.

EE 3431. Junior Electrical Engineering Laboratory III
0-3-1. Prerequisites: EE 3270, 3400.

Presentation of topics for experimentation in circuits and electronics which illustrate the operation and application of integrated circuits.


EE 3701. Electric Circuits
2-0-2. Prerequisite: MATH 2308, PHYS 2122.

For non-electrical engineering students. Study of electric circuit elements and of the steady-state and transient response of circuits to periodic and step inputs.

Text: Fitzgerald et al., Basic Electrical Engineering.

EE 3702. Elementary Electronics
2-0-2. Prerequisite: EE 3701.

For non-electrical engineering students. An introduction to electronic and semiconductor devices and a study of circuits containing such elements. Both linear and digital circuits are considered.

Text: Fitzgerald et al., Basic Electrical Engineering.

EE 3703. Electric Power Conversion
2-0-2. Prerequisite: EE 3701.

For non-electrical engineering students. A study of energy conversion principles and devices such as motors, generators, transformers, and rectifiers.

Text: Fitzgerald et al., Basic Electrical Engineering.

EE 3900-1-2-3. Special Problems
Credit to be arranged. Normally taken by juniors.

Special engineering problems are assigned according to each student's needs, interests, and capabilities.

EE 4011. Analog Filter Design
3-0-3. Prerequisite: EE 3220.

An introduction to the theory, design techniques, and applications of analog passive and active filters.

Text: Johnson, Introduction to Filter Theory.

EE 4012. Electric Energy Conversion
3-3-4. Prerequisite: EE 3330.


Text: Match, Electromagnetic and Electromechanical Machines.

EE 4015. Principles of Feedback Control
3-3-4. Prerequisite: EE 3220.

A study of automatic control systems. Basic control principles, system modeling, and analysis techniques. Coordinated laboratory exercises.

Text: D'Azio and Houpis, Linear Control System Analysis and Design.

EE 4017. Pulse Circuits
3-0-3. Prerequisite: EE 3270.

Analysis and design for processing analog and digital data, generation and synchronization of sweeps, switching considerations of MOSFET multivibrators, active-element memories, D-A. and A-D converters.

Text: Millman, Microelectronics.

EE 409. Power System Analysis
3-0-3. Prerequisite: EE 3330 or consent of School.

A study of power systems, power system components, and their effects on the power system. Coordinated laboratory exercises.


EE 4021. Electromagnetic Properties of Solids
3-3-4. Prerequisite: EE 4350.

Properties of dielectric and magnetic materials including piezoelectricity, superconductivity, magnetic domain dynamics, and ferromagnetic resonance. Applications as transducers, memories, logic elements, and microwave devices.

EE 4022. Industrial Electronics
3-3-4. Prerequisites: EE 3210, 3270, 3360.

A study of analog and digital process control including signal conditioning, transducers, actuators, and control elements.

Text: Johnson, Process Control Instrumentation Technology.

EE 4023. Integrated Circuits and Systems
3-0-3. Prerequisite: EE 3270.

A study of integrated circuit technology available today. The merits and drawbacks to electronic applications offered by circuit configurations available in digital and linear ICs.

Text: Millman, Microelectronics.

EE 4024. Speech Analysis, Synthesis, and Compression
3-0-3. Prerequisite: EE 3210 or consent of School.

Modern speech analysis and synthesis techniques as applied to the communication problem of speech synthesis. Classical phonology, vocoders, vocal track analogs, spectral analysis of speech.


EE 4025. Information Theory
3-0-3. Prerequisite: EE 3340 or equivalent.

Definitions and applications of the measure of information, redundancy, channel, channel capacity and mutual information and Shannon's coding theorems are presented with emphasis on communication problems.

Text: Hamming, Coding and Information Theory.

EE 4026. Audio Engineering
3-0-3. Prerequisites: EE 3270, 3310.


EE 4027. Computer Graphic Design
3-0-3. Prerequisites: EE 4010 or equivalent and junior standing.

Principles of computer-aided design (CAD), with emphasis on interactive graphics. Engineering applications and introduction to hardware and programming for interactive computing.


EE 4028. Communication Engineering
3-0-3. Prerequisites: EE 3210, 3270.

Circuit design for communication systems operating below one gigahertz. Impedance matching, introduction to random noise, small signal and power amplifiers, primarily for analog system applications.

EE 4030. Communication Engineering
3-0-3. Prerequisites: EE 3210, 3270.
**EE 4031. Microwave Devices and Circuits**
3-0-3. Prerequisite: EE 3210 or School.
Introduction to microwave and millimeter wave engineering, including waveguide and transmission line structures, passive microwave components and active sources.

**EE 4033. Network Synthesis**
3-0-3. Prerequisite: EE 4350 or consent of School.
A study of the properties of linear sequential systems in relation to their applications in various digital tasks.

**EE 4035. High Frequency Amplifier Design**
3-0-3. Prerequisites: EE 4350 or consent of School.
An introduction to the techniques used in the design of high frequency amplifiers with emphasis placed on design.

**EE 4037. Antennas**
3-3-4. Prerequisite: EE 3320.
Introductions to linear antennas, linear arrays, and aperture antennas. Far field pattern calculation and measurement are presented. Students design and construct antennas in an associated laboratory.

**EE 4039. Electrical Sensors and Transducers**
3-0-3. Prerequisite: senior standing or consent of School.
Survey of how electrical sensors function and their application. Topics include sensors such as: thermocouples, strain gauges, photoelectric cells, and magnetic sensors.

**EE 4041. Illumination Engineering**
3-0-3. Prerequisites: PHYS 2123, EE 3310.
An introduction to interior and exterior lighting design. Basic topics considered are light, sight, color, photometry, illumination, luminaires, and sources.

**EE 4043. Linear Graph Theory**
3-0-3. Prerequisite: EE 3310.
Comprehensive and unified study of oriented and nonoriented graphs for use in network topology, analysis and synthesis, signal flow theory, and communication networks.

**EE 4045. Power System Protection**
3-0-3. Prerequisite: EE 4019.
An introduction to fundamental concepts in the protection of electric power system apparatus.

**EE 4046. Power System Engineering**
3-0-3. Prerequisite: EE 4019.
Modeling of power system elements and components, elements of steady state operation and power system protection.

**EE 4047. Power Electronics**
3-0-3. Prerequisite: EE 3270.
An introduction to power semiconductor devices and to the electronic circuits incorporating these devices that can be used to the amplification, generation, and control of electrical energy.

**EE 4050. Optical Engineering**
3-0-3. Prerequisite: EE 3320 or consent of School.
Introduction to optics and optical systems as applied to modern engineering problems. Image formation, holography, optical data processing, optical memories, specification of optical systems, fiber optics.

**EE 4051. Fiber Optics**
3-0-3. Prerequisite: EE 3310 or consent of School.
Exploration of state-of-the-art material related to the fabrication, measurement, and use of optical fibers. Development of the theory of dielectric waveguides.

**EE 4055. Semiconductor Device Electronics**
3-0-3. Prerequisite: EE 4350 or consent of School.
An introduction to the basic physical principles involved in the analysis of semiconductor devices important to microelectronics and instrumentation.

**EE 4056. Integrated Circuit Fabrication**
3-0-3. Prerequisite: EE 4055 or EE 4023.
A basic study of the fabrication processes required to create silicon integrated circuits. Emphasis is placed on wafer processing techniques and device realization.

**EE 4057. Integrated Circuit Device Electronics**
3-0-3. Prerequisite: EE 4055 or equivalent.
A detailed examination of the active devices important in high-density integrated circuits. Emphasis is placed on advanced device physics and design aspects.

**EE 4061. Communication Systems**
3-0-3. Prerequisites: EE 3340 or equivalent, EE 3215.
Definitions, basic concepts, and applications of analog and digital modulation techniques are considered. Modulators for generating various signals and demodulators for information recovery are studied.

**EE 4062. Communication Systems Laboratory**
0-3-1. Prerequisites: EE 3340 or equivalent, EE 3400. Corequisite: EE 4061.
Experiments in signal processing and communication systems.

**EE 4072. Automatic Measurements**
2-3-3. Prerequisite: EE senior standing.
An introduction to measurements carried out by instruments and a programmable controller via the IEEE-488 general purpose interface bus.

**EE 4074. Local Computer Networks**
3-0-3. Prerequisites: EE 3032 and a course in probability.
An introduction to the design and performance analysis of local computer communication networks. Emphasis is placed on the design of various network topologies and protocols.

**EE 4075. Microcomputer-based Design**
3-3-4. Prerequisites: EE 3032 and EE 3360 or equivalent.
Development of the ability to define and design "smart" microcomputer-based instruments is emphasized.

**EE 4076. Special Purpose Digital Systems Design**
3-0-3. Prerequisites: EE 3360 and EE 4075.
Digital circuits which augment the capabilities of a microcomputer are discussed. Design for maintainability is emphasized.

**EE 4078. Digital Signal Processing**
3-0-3. Prerequisite: EE 4215.
An introduction to the theory and application of processing discrete data. Special attention will be paid to the design and implementation of both FIR and IIR digital filters.

**EE 4079. Introduction to Automation Theory**
3-0-3. Normally taken by seniors.
A study of the properties of linear sequential systems in relation to their applications in various digital tasks.

**EE 4080. Introduction to Sequential Systems**
3-0-3. Prerequisite: EE 3360 or equivalent.
A study of processes for synthesis of synchronous and asynchronous sequential systems.

**EE 4081. Introduction to Bioelectronics**
3-0-3. Prerequisite: EE 3370 or consent of School.
An introduction to the study of the electrical phenomena of biological systems. The measurement and control of biological systems.

**EE 4082. Linear System Theory**
3-0-3. Prerequisite: EE 3220.
Linear system theory with emphasis on transform and state-variable methods. Applications to both continuous and discrete systems.

**EE 4083. Computer Simulation of Systems**
3-0-3. Prerequisite: EE 3220.

**EE 4084. Transistor Circuit Analysis**
3-0-3. Prerequisite: EE 3270. Corequisite: EE 4085.
Analysis and design of linear electronic circuits. Single stage amplifiers, multistage amplifiers, tuned amplifiers with emphasis on design techniques.

**EE 4085. Electronic Design Laboratory**
0-3-1. Corequisite: EE 4084.
Practical design problems which emphasize creativity and imagination are posed and their solutions are individually implemented in the laboratory.

**EE 4086. Operational Amplifier Design**
3-0-3. Prerequisite: EE 3270.
Theory and applications of operational amplifiers as they are currently utilized in today's electronic systems to produce both linear and nonlinear functional operations.

**EE 4087. Biomedical Instrumentation**
3-0-3. Prerequisite: EE 3220 or PHYS 2122. Instrumentation used in the hospital and clinic from a systems viewpoint. Includes a review of pertinent physiological and electrophysiological concepts.

**EE 4090. EE Senior Seminar**
1-0-1. Prerequisite: EE junior standing.
A senior seminar open to all engineering students. Topics include professional development, current issues in the electrical engineering field, and preparation for the job market.

**EE 4095. Electrical Transients in Power Systems**
3-0-3. Prerequisite: EE 4019 or consent of School.
Analysis of transient conditions in power systems. System parameters. Types of transients. Protective devices and techniques.

**EE 4350. Materials Science**
3-0-3. Prerequisites: EE 3320, 3270.
A study of the physical, electrical, and optical properties of metals, semiconductors, dielectrics, and magnetic materials with emphasis on microscopic as well as macroscopic behavior.

**EE 4411. Senior Electrical Engineering Laboratory I**
0-3-1. Prerequisite: EE 3400. Corequisite: EE 3320.
The use, operation, and limitations of standard electromagnetic field measurement and signal generating equipment.

**EE 4421. Senior Electrical Engineering Laboratory II**
0-3-1. Prerequisite: EE 3400. Corequisite: EE 3330 (for electrical engineering students) or EE 3703 (for non-electrical engineering students).
Experimental studies of electromagnetic field and electromagnetic systems.
EE 4430. Project Laboratory
3-0-3. Prerequisite: EE 3400. Normally taken by seniors.
Individual experimental investigations and projects tailored to student interests. Projects are selected in consultation with student's faculty adviser.

EE 4751. Laser Theory and Applications
3-0-3. Prerequisite: PHYS 2123.
Principles of laser operations. Types of lasers. Survey lectures on the applications of lasers to various fields. Course intended for both EE and non-EE majors. Also taught as PHYS 3751.
Text: O'Shea, Introduction to Lasers and Their Applications.

EE 4780. Energy Conversion Engineering
3-0-3. Prerequisite: thermodynamics.
Principles of advanced energy conversion for electric power. Operation and engineering considerations. Also taught as ME 4780 and NE 4780.
Text: Angrist, Direct Energy Conversion.

EE 4801-2-3-4-5. Special Topics
3-0-3 each. Normally taken by seniors.
New developments in electrical engineering are presented as demand or interest warrants.

EE 4900-1-2-3. Special Problems
Credit to be arranged. Normally taken by seniors.
Special engineering problems are assigned according to each student's needs, interests, and capabilities.

EE 6059. Random Processes I
3-0-3. Prerequisite: graduate standing.
An introduction to the concepts of probability theory and random variables with applications to electrical engineering problems.

EE 6051. Random Processes II
3-0-3. Prerequisite: EE 6050 or equivalent.

EE 6057. Telecommunication I
3-0-3. Prerequisites: EE 6050, EE 6070, or equivalent.
Basic binary and M-ary digital signalling techniques with emphasis on the effects of noise. Performance analysis and comparisons of alternative systems.

EE 6058. Telecommunication II
3-0-3. Prerequisite: EE 6057.
Introduction of EE 6057. Intermodulation interference, patrol response systems, and synchronization techniques and other signalling techniques.

EE 6063. Methods in Pattern Recognition
3-0-3. Prerequisite: EE 6050.
Introduction to pattern recognition. Several approaches to pattern classification, feature extraction, and training are considered including the use of linear discriminant functions, clustering, gradient methods, and syntactic pattern recognition. Several examples of pattern recognition systems are also included.

Design techniques for stochastic dynamical systems. Analysis of stochastic systems, state estimation, stochastic control, and adaptive control.

EE 6133. Feedback Control Systems
3-0-3. Prerequisite: EE 6100.
Application of discrete time control to continuous systems. Time and frequency domain analysis of sampled data systems.

EE 6131. Optimum Linear Filters
3-0-3. Prerequisites: EE 6050, 6100 or consent of School.
Estimation theory, both classical and modern approaches. Applications in communication and control. System identification techniques.

EE 6152. Computer Simulation
3-0-3. Prerequisites: graduate standing or consent of School.
as part of the course. EE 6161.
Digital Systems Engineering I
3-0-3. Prerequisite: EE 3400. Normally taken by seniors.
Introduction to information theory. The concepts of information, information rate, and channel capacity are developed and applied to communication theory problems.

EE 6082. Coding
3-0-3. Prerequisite: graduate standing or consent of School.
Coding techniques for efficient, reliable communication are introduced. Techniques include parity-check, maximal-length, Hamming, BCH and convolutional codes, Viterbi decoding and coding for burst-noise channels.

EE 6092. Computer Communication Systems
3-0-3. Prerequisite: graduate standing.
A study of the basic concepts of computing structures and their impact on performance. Data types, addressing modes, fixed and floating point instruction timing, cache memory operation, error detection and correction, memory mapping, virtual memory, and parallel processing.

EE 6162. Digital Systems Engineering II
3-0-3. Prerequisite: EE 3033, 4075.
A study of the basic concepts of computing structures and their impact on performance. Data types, addressing modes, fixed and floating point instruction timing, cache memory operation, error detection and correction, memory mapping, virtual memory, and parallel processing.

EE 6163. Digital Systems Engineering III
3-0-3. Prerequisite: EE 6332, 4075.
A study of information structures. Structures include stacks, queues, circular lists, linked lists, doubly linked lists, trees, and collection of memory arrays, and orthogonal lists. Dynamic allocation is also treated.

EE 6170. Advanced Microcomputer-based Design
2-3-3. Prerequisite: EE 4075 or equivalent.
The study of software development for instrument design applications. High level language and assembly language are applied in a real-time operating system environment.

EE 6201. Automata Theory I
3-0-3. Prerequisite: graduate standing.
An introduction to broad classes of digital systems including computer components as special cases. A detailed study is made of steps leading to optimum design.

EE 6202. Automata Theory II
3-0-3. Prerequisite: EE 6201.
A continuation of digital system study including fault detection and decomposition of systems. Reliability, memory span, and quadded logic are also examined.

EE 6203. Automata Theory III
3-0-3. Prerequisite: EE 602 or consent of School.
An introduction to finite automata through study of sequential circuits. Concepts in modern algebra are developed for direct application to sequential circuits.

EE 6251. Applied Electromagnetics
3-0-3. Prerequisite: graduate standing or consent of School.
Advanced electromagnetic theory. Particular and complementary solutions of the wave equation for both discrete and continuous cases. Analysis, synthesis, and boundary value problems.

EE 6252. Microwave
3-0-3. Prerequisite: EE 6251.

EE 6250. Microelectronics
3-0-3. Prerequisite: EE 6251.

EE 6250. Microelectronics
3-0-3. Prerequisite: graduate standing or consent of School.

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3-0-3. Prerequisite: graduate standing or consent of School.

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3-0-3. Prerequisite: graduate standing or consent of School.

EE 6250. Microelectronics
3-0-3. Prerequisite: graduate standing or consent of School.

EE 6250. Microelectronics
3-0-3. Prerequisite: graduate standing or consent of School.
EE 6361. Integrated Circuits
3-0-3. Prerequisite: graduate standing.
Design, fabrication, and application considerations of monolithic linear ICs. Analysis of unconventional circuitry contained in typical integrated circuits. Applications of available linear ICs.

EE 6362. Switched Capacitor Filters
3-0-3. Prerequisite: graduate standing or consent of School.
A study of the application of MOS integrated circuit technology and analog sampled data theory for the realization of active filters.

EE 6363. Analog MOS Circuit Design
3-0-3. Prerequisite: graduate standing or consent of School.
A study of the analysis and design of operational amplifiers, analog switches, digital-to-analog and analog-to-digital converters using modern MOS FET technology.

EE 6380. Frequency Synthesizers
3-0-3. Prerequisite: graduate standing or consent of School.
The study of generating any arbitrary frequency from a given frequency standard. Digital and analog phase-locked loops, frequency mixers, spurious signals, and phase noise are considered.

EE 6381. Low-Noise Electronic Design
3-3-4. Prerequisite: graduate standing or consent of School.
Sources of noise in electronic instrumentation design and employment of design techniques to reduce the effects of noise.

EE 6404. Network Analysis and Synthesis
3-0-3. Prerequisite: graduate standing.
Special network analysis techniques beyond the typical undergraduate treatment, including a brief introduction to linear network synthesis.

EE 6405. Analog Passive Filters
3-0-3. Prerequisite: EE 6404.
A survey of various techniques of analog passive filter design aimed at enabling students to design practical filters by understanding the underlying principles.

EE 6406. Analog Active Filters
3-0-3. Prerequisite: EE 6405.
Methods of designing continuous-time active filters using resistors, capacitors, and operational amplifiers as constituent elements. Sensitivity criteria are emphasized.

EE 6413. Digital Filters
3-0-3. Prerequisite: EE 6404.

EE 6414. Advanced Digital Signal Processing
3-0-3. Prerequisite: EE 4078 or 6413.
A selection of advanced topics in digital signal processing. Topics include homomorphic systems, autoregressive modelling, adaptive filtering, and power spectrum estimation.

EE 6415. Digital Processing of Speech Signals
3-0-3. Prerequisite: EE 4078 or EE 6413.
A detailed treatment of the theory and application of digital speech processing. Provides fundamental knowledge about speech signals and speech processing methods. A study of digital techniques applied in speech transmission, speech synthesis, speech recognition, and speaker verification.

EE 6416. Multidimensional Digital Signal Processing
3-0-3. Prerequisite: EE 6413.
An introduction to the analysis and manipulation of signals of more than one independent variable, such as image processing, 3-D sensing, and sensors. Topics covered include multidimensional digital filtering and multidimensional spectrum analysis.

EE 6417. Multidimensional Architectures for Digital Signal Processing
3-0-3. Prerequisite: EE 6413.
An introduction to the use of graph-theoretic, matrix, and statistical techniques to the implementation of digital signal processing algorithms by multiprocessor computers. Topics covered include matrix representations for flow graphs, finite word length effects, and synchronous and asynchronous implementations.

EE 6421. Advanced Network Theory I
3-0-3. Prerequisite: graduate standing or consent of School.
An introduction to applied combinatorics including combinations, permutations, recursion, partition, generating functions, inclusion and exclusion, rook polynomials, and Polya’s theorem.

EE 6431. Electroracoustics
3-0-3. Prerequisite: graduate standing or consent of School.

EE 6451. Electrical Properties of Materials
3-0-3. Prerequisite: graduate standing or consent of School.
Basis of quantum mechanical formalism and modeling to serve as an introduction to the modern study of electrical properties of materials.

EE 6452. Magnetic and Dielectric Properties of Materials
3-0-3. Prerequisite: EE 6451 or consent of School.
Dielectrics, piezo- and ferroelectrics and their applications in electromechanical devices. Quantum basis of magnetism. Magnetic interactions, domains, resonance, and devices.

EE 6453. Solid-state Electronic Devices
3-0-3. Prerequisite: graduate standing or consent of School.
Study of charge and energy transport in semiconductors with applications in pn junction, interface and thin film, optoelectronic and bulk-effect devices.

EE 6454. Microstructure Fabrication Techniques
3-0-3. Prerequisite: EE 6431.
An examination of the physics, chemistry, and integration circuit engineering techniques required to fabricate device structures with dimensions in the micron region.

EE 6461. Modern Magnetic Materials and Devices
3-0-3. Prerequisite: EE 4542 or consent of School.
Basic operation and design of magnetic memories and microwave devices. Structure, crystal structure, chemical composition. Properties of ferrites, garnets, and orthoferrites.

EE 6500. Introduction to Management and Control of Energy Systems
3-0-3. Prerequisite: EE 6100 or consent of School.
Fundamentals of static as well as dynamic system theory as applied to typical energy engineering problems. Optimization theory, decision analysis techniques for large-scale systems.

EE 6501. Planning of Power Systems
3-0-3. Prerequisite: EE 4019 or consent of School.
An introduction to planning procedures for large scale technical operations. Techniques and economic constraints on planning. Techniques for formulation of rational planning problems.

EE 6502. Control and Operation of Interconnected Power Systems
3-0-3. Prerequisite: EE 4019, 6100, or consent of School.
Power flow analysis techniques. Modern control of power systems with emphasis on security, economic and environmental issues.

EE 6503. Evaluation of Power System Reliability
3-0-3. Prerequisite: EE 4019 or consent of School.
Techniques for the study of power system reliability. Probabilistic models for power system performance. Techniques for subsystem and composite system reliability analysis.

EE 6511. Transmission Lines
3-3-4. Prerequisite: graduate standing.
A study of electrical power transmission line parameters, models and techniques for analysis of steady state and transient conditions. A.C., D.C., HV and underground transmission.

EE 6520. Real-Time Control of Power Systems
3-0-3. Prerequisite: EE 4019, 6100, or consent of School.

EE 6521. Power System Stability
3-0-3. Prerequisite: EE 4019, 6100.
Methods of stability analysis of interconnected power systems. System modeling, analysis techniques for determination of static and dynamic stability.

EE 6530. Power Semiconductor Devices
3-0-3. Prerequisite: graduate standing or consent of School.
The study of the physical considerations involved in the use of heavy-current semiconductor devices.

EE 6531. Solid-State Power Conversion
3-0-3. Prerequisite: graduate standing or consent of School.
The study of the physical and electrical considerations involved in the analysis and design of solid-state inverters and converters.

EE 6550. Multivariable System Theory
3-0-3. Prerequisite: EE 6100.
Structural properties, controllability, observability, canonical forms. Applications to pole-shifting, decoupling, system realization and identification. Introduction to multi-dimensional systems.

EE 6773. Computer Control of Real-time Systems
3-3-4. Prerequisite: EE 4019 or consent of School.
The study of concepts common to all computer controlled real-time systems. Subjects include evolution of time sets, vectorized interrupts and statistical alarm conditions. Also taught as EE 6773, ME 6773, and NE 6773.

EE 6965. Power System Relaying
3-3-4. Prerequisite: EE 4019 or consent of School.
Principles and techniques of electric power system protection. Application of relaying techniques for system stabilization, protection of high voltage transmission system and substations. Coordinated field trips and demonstrations.

EE 6976. Advanced Electrical Transients
3-0-3. Prerequisite: graduate standing or consent of instructor.
Development and application of those aspects of complex variable and transform theory which are helpful in the study of transients and which are particularly useful to electrical engineers in general.

EE 7000. Master's Thesis
3-0-3. Prerequisites: EE 6501, 6511.
Latest developments in communications are treated in lecture and seminar. Emphasis on current literature and open research areas.

EE 7101. Advanced Feedback Control Theory
3-0-3. Prerequisite: EE 6100 or equivalent.
Advanced techniques for analysis and design of automatic control systems.

EE 7251-2-3. Advanced Electromagnetic Theory
3-3-4 each. Prerequisite: EE 6251 or consent of School.

General Information
The School of Engineering Science and Mechanics administers the undergraduate curriculum leading to the degree Bachelor of Engineering Science and Mechanics and graduate programs leading to the degrees Master of Science, Master of Science in Engineering Science and Mechanics, and Doctor of Philosophy.

The undergraduate curriculum prepares students for careers in engineering and related fields through emphasis on the fundamental principles and techniques in mathematics and the engineering sciences—solid mechanics, fluid mechanics, materials science, electrical sciences, heat transfer, and thermodynamics. The curriculum, totaling 206 credit hours, provides for 74 hours of electives, including 16 hours of free electives, 30 hours of technical electives, 24 hours of humanities/social science/modern language electives, and 4 hours of physical education electives. The engineering science and mechanics curriculum is considered particularly well suited to the better-than-average student who has not yet formulated specific goals within the general framework of engineering and the physical sciences.

Elective options provide in-depth study in interdisciplinary, technically related areas as well as preparation for professional schools of business, law, and medicine. Thus, the engineering science and mechanics graduate has a wide choice of specialized areas that can provide a foundation for starting his or her career or for entering graduate study.

Graduate study and research in the School of Engineering Science and Mechanics includes work in modern continuum mechanics, stress analysis, stability, structures, dynamics, vibrations, space mechanics, fracture mechanics, finite element methods and other computational techniques, fluid mechanics, biomechanics, acoustics, wave propagation, applied stochastic processes, optimization techniques, materials science, and experimental stress analysis. The ESM graduate student will also find a great number of related courses in the other schools of the Institute. The School encourages flexibility and interdisciplinary interests in the planning of individual programs of study.

The faculty members of the School of Engineering Science and Mechanics hold degrees in most of the recognized branches of engineering as well as in mathematics and physics. Housed in two buildings, ESM has excellent classroom, office, and shop facilities and modern, newly equipped laboratories. Various grants, assistantships, and fellowships are available to students of outstanding merit.

Multidisciplinary Programs
See table on page 78.

Curriculum

Freshman Year

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<tr>
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<tr>
<td>CHEM 1101-2 Inorganic Chemistry</td>
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<td>EGR 1170 Visual Communication Engineering Design I</td>
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<tr>
<td>MATH 1307-8-9 Calculus I, II, III</td>
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<td>5-0-5</td>
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<tr>
<td>PHYS 2121 Physics</td>
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<td>ENGL 1001-2 Analysis of Literature and Language</td>
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<td>Elective^2 English</td>
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<td>Elective^3 Free</td>
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<td>Elective^4 Physical Education</td>
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Sophomore Year

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<td>ESM 2101-2 Engineering Design I, II</td>
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<td>ESM 2201 Statics</td>
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<td>ESM 3201-2 Dynamics I, II</td>
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<tr>
<td>EE 3200 Elements of Electrical Engineering</td>
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Junior Year

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<tr>
<td>ESM 3111 Experimental Methods in Engineering Science</td>
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<td>2-3-3</td>
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<tr>
<td>ESM 3301 Mechanics of Deformable Bodies</td>
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<tr>
<td>ESM 3302 Mechanics of Materials</td>
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<tr>
<td>ESM 3501 Fluid Mechanics</td>
<td>5-0-5</td>
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<tr>
<td>ESM 4210 Mechanical Vibrations</td>
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<tr>
<td>EE 3250 Elements of Electrical Engineering</td>
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<tr>
<td>EE 3400 Instrumentation Laboratory</td>
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<td>ENGL 3020 Technical Writing</td>
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<td>ME 3322 Thermodynamics</td>
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<td>ME 3323 Thermodynamics</td>
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<tr>
<td>ME 3345 Conduction and Radiation Heat Transfer</td>
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<td>Elective^5 Mathematics</td>
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<tr>
<td>Electives Humanities/Social Science/Modern Language</td>
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Totals 15-6-17 15-9-18 17-0-17

Multidisciplinary Programs
See table on page 78.
Courses of Instruction

Note: Some ESM courses are offered on an alternate-year basis. The designations "even years" in a course description refers to even academic years, e.g., 82-83, 84-85. "Odd years" refers to odd academic years, e.g., 83-84, 85-86.

ESM 1101. Introduction to Engineering
1-6-3.
"The engineer and design, relation between the student's curriculum and his or her career in engineering. Emphasis placed on student participation in creative design process."
 Text: at the level of Beakley and Leach, Engineering: An Introduction to a Creative Profession.

ESM 1750. Introduction to Bioengineering
3-0-3.
"Bioengineering aspects of human body including its mechanics, nervous system control, material properties, and biological fluid flows. Diagnostic techniques and assisting and replacement prosthetic devices. Also listed as AE 1750, CHE 1750, EE 1750, ME 1750.

ESM 2101. Engineering Design
0-3-1. Prerequisite: ESM 1001 or consent of School.
"Study of a problem that arises from a need of society. Proposals for a creative solution studied to select best design. Substitution permissible for co-ops.

ESM 2102. Engineering Design II
0-6-2. Prerequisite: ESM 2101.
"Continuation of ESM 2101. Solution of design problem. To be completed, a model to be submitted as part of final report.

ESM 2201. Statics
3-0-3. Prerequisite: PHYS 2121. Prerequisite or corequisite: MATH 2307.

ESM 3111. Experimental Methods in Engineering Science and Mechanics
2-3-3. Prerequisites: EE 3400, MATH 2309, ESM 3201, 3301, ENGL 3020.
"Methods used to observe behavior of physical parameters in engineering problems, photooptics, signal analysis, transducers and transducer circuits, models and analogies. Text: at the level of Tuve and Dohrholdt, Engineering Instrumentation.

ESM 3112. Bioengineering Measurements
3-0-3. Prerequisite: junior standing in engineering or consent of instructor.
"Medical diagnostic procedures are described after studying the relevant physiology and the applied engineering principles. Text: at the level of Cromwell, Weibell, and Pfeiffer, Biomedical Instrumentation and Measurements.

ESM 3201. Dynamics I
3-0-3. Prerequisites: ESM 2201, MATH 2307.
"Kinematics and kinetics of rigid bodies in plane motion. Text: at the level of Higdon, Stiles, Davis, and Evces, Dynamics.

ESM 3202. Dynamics II
3-0-3. Prerequisite: ESM 3201.
"Kinematics and kinetics of three-dimensional motion of rigid bodies. Text: at the level of Higdon, Stiles, Davis, and Evces, Dynamics.

ESM 3301. Mechanics of Deformable Bodies
3-0-3. Prerequisite: ESM 3301.
"Analysis and design of beams (using singularity functions), various structural elements (using energy methods), thick-walled cylinders, rotating discs, curved beams. Theories of failure. Text: at the level of Popov, Introduction to Mechanics and Solids.

ESM 3302. Mechanics of Materials
3-0-3. Prerequisite: ESM 3301.
"Analysis and design of beams using singularity functions, various structural elements (using energy methods), thick-walled cylinders, rotating discs, curved beams. Text: at the level of Budynas, Advanced Strength and Applied Stress Analysis.

ESM 3451. Computer Applications in Engineering Science and Mechanics
2-3-3. Prerequisite or corequisite: ESM 3302, 3501, 4210, or consent of School.
"Introduction to the use of the digital computer. FORTRAN languages, computer solutions of problems in statics, dynamics, mechanics of deformable solids, vibrations, and fluid mechanics.

ESM 3452. Microcomputers in Engineering Science
3-0-3. Prerequisite: junior standing.
"An introduction to microcomputers emphasizing laboratory applications in the engineering sciences; data conversion and display control of experiments. Project in areas of robotics, digital control, speech synthesis, and others.

ESM 3501. Fluid Mechanics
3-0-5. Prerequisites: MATH 2309 or 3308 and ESM 3202.

ESM 3701. Statics
3-0-3. Prerequisites: ARCH 2301, MATH 1309, PHYS 1211.
"Elements of coplanar statics, particle and rigid body equilibrium, centroids, centers of gravity, distributed loads, analysis of structures and beams, shear and bending moment. Text: at the level of Beer and Johnston, Mechanics for Engineers: Statics.

ESM 3702. Mechanics of Materials
3-0-3. Prerequisite: ESM 3701.
"Simple stresses and strains, mechanical properties of materials, Hooke's Law, moments of inertia of areas, analysis and design of beams and columns, deflection of beams. Text: at the level of Popov, Mechanics of Materials.

ESM 3750. Introduction to Biofluid Dynamics
3-0-3. Prerequisite: MATH 2309, PHYS 2123, or consent of instructor.
"Introduces students to the study of blood flow in the cardiovascular system, with emphasis on the modeling of such flows and the potential of flow studies for clinical research application. Also taught as AE 3750 and CHE 3750.

ESM 3901 through 3909. Special Problems in Engineering Science and Mechanics
Credit to be arranged. 3 hours maximum. Prerequisite: junior standing.
"Individual study and analysis of problems of current and future interest in engineering and science, approved by faculty adviser.

ESM 4111. Introduction to Experimental Stress Analysis
1-6-3. Prerequisites: ESM 3301 or equivalent, senior standing.
"Plane stress analysis using transmitted light photoelasticity and photoelastic models, study of surface strain using resistance strain gauges, transducer design and application. Text: at the level of Holister, Experimental Stress Analysis.

ESM 4122. Project in Engineering Science and Mechanics I
0-3-1. Prerequisite: senior standing in Engineering Science and Mechanics.
"Through discussions with the faculty adviser and other members of the faculty, students will determine the design-related engineering problem that they wish to study. A detailed written project proposal will be submitted to and approved by the student's faculty project adviser prior to the end of the quarter.

ESM 4123. Project in Engineering Science and Mechanics II
0-6-2. Prerequisite: ESM 4122.
Continuation of ESM 4122. Student will complete an experimental and/or theoretical investigation of an engineering problem and submit a written report for the approval of his/her faculty project adviser.

**ESM 4201. Intermediate Dynamics I**
3-0-3. Prerequisite: ESM 3201 or consent of School. Dynamics and vibrations at the level of Timoshenko, Young, Weaver, Vibration Problems in Engineering.

**ESM 4202. Intermediate Dynamics II**
3-0-3. Prerequisite: ESM 4201 or consent of School. Two- and three-dimensional motion of a rigid body. Euler's equations, introduction to energy methods, and Lagrange's equations.

**ESM 4210. Mechanical Vibrations I**
3-0-3. Prerequisites: ESM 3201, 3301 and MATH 2309 or equivalent. Single degree-of-freedom system, two degrees-of-freedom system, and finitely many degrees-of-freedom system, complex representation, applications.

**ESM 4211. Mechanical Vibrations II**
3-0-3. Prerequisites: ESM 4210 and ESM 3302 or equivalent. Complex representation, step and impulse loads, many degrees-of-freedom, influence coefficients, matrix methods, stability of solution, vibrations of strings, beams and membranes, approximate methods.

**ESM 4301. Mechanics of Deformable Bodies**
3-0-3. Prerequisite: ESM 3301. Small strain linear elasticity in two and three dimensions, applications in generalized plane stress and plane strain, torsion and bending of non-circular prisms.

**ESM 4302. Stress Analysis**
3-3-4. Prerequisite: ESM 4301. Continuation of ESM 4301, further treatment of torsion and bending, stress energy, introduction to thin plates and simple shells, approximation methods.

**ESM 4351. Continuum Mechanics**
3-0-3. Prerequisites: MATH 2309, ESM 3301. Geometrical foundations, analysis of stress and deformation, balance laws, constitutive equations, finite and infinitesimal elasticity.

**ESM 4452. Biomechanics**
3-0-3. Prerequisites: MATH 2309 or equivalent, ESM 3301 or equivalent. The mechanics of living tissue, e.g., arteries, skin, heart muscle, and bone. Constitutive equations for tissues and some simple mechanical models. Biomechanical instrumentation.

**ESM 4453. Biosystems Analysis**
3-0-3. Prerequisite: MATH 2309 or 3308 or equivalent. Different analytical methods for modeling biological systems are described, including a white-noise protocol for characterizing nonlinear systems. Text: at the level of Marmarellis and Marmarellis, Analysis of Physiological Systems.

**ESM 4760. Engineering Acoustics and Noise Control I**
3-0-3. Prerequisite: senior standing. Acoustics related to noise and its control, acoustic terminology, wave propagation, solutions to the wave equation, instrumentation, sound field in large and small rooms, noise legislation. Also taught as AE 4760, ME 4760.

**ESM 4761. Engineering Acoustics and Noise Control II**
3-0-3. Prerequisite: ESM 4760 or equivalent. Continuation of ESM 4760 emphasizing techniques for the solution of noise problems. Vibration isolation, energy absorption, dissipative and reactive mufflers, enclosures, barriers, properties of materials, panel damping. Also taught as AE 4761, ME 4761.

**ESM 4770. Structural Integrity and Durability**
3-0-3. Prerequisite: ESM 3301 or AE 2101. Simple stress-concentration problems involving plastic deformation, residual stresses, hysteresis, creep, and relaxation. Introduction to fatigue and fracture mechanics. Crack-growth calculations and wearout models. Also taught as AE 4770.

**ESM 4801 through 4809. Special Topics in Engineering Science and Mechanics**
1-0-1 through 9-0-9, respectively. Prerequisite: senior standing. Special courses not included in regular course offerings.

**ESM 4901 through 4909. Advanced Engineering Science and Mechanics**

**ESM 6118. Experimental Mechanophysics II**
2-3-3. Prerequisite: ESM 6117. Winter quarter, odd years. Three-dimensional photoelastic stress analysis using transmitted light and scattered light methods, numerical methods, photoelastic models, use of transmitted light for stress analysis in two-dimensional problems, birefringent coatings.

**ESM 6119. Structural Integrity and Durability**
3-0-3. Prerequisite: ESM 6118 or equivalent. Continuation of ESM 6118. Winter quarter, even years. Celestial sphere, aberration, parallax, Laplace's and Gauss' methods, three- and n-body problems, Lagrange's points, Lagrange's equations, perturbations of an oblate planet, and atmospheric drag.

**ESM 6281. Random Vibrations I**
3-0-3. Prerequisites: ESM 4215 and ESM 4210, or consent of School. Fall quarter, even years. Statistical analysis of mechanical systems, correlation function, power spectral density, response to random inputs, method of normal modes, fatigue failures, nonstationary inputs, vibration of beams.

**ESM 6282. Random Vibrations II**
3-0-3. Prerequisite: ESM 6281. Winter quarter, even years.

**ESM 6283. Stress Analysis**
3-0-3. Prerequisites: ESM 3201, 3301 and MATH 2309 or equivalent. Containment of ESM 6281. Advanced engineering problems in random theory, nonstationary random inputs and response, measurement of power spectra, Fokker-Planck techniques, nonlinear systems.

**ESM 6301. Advanced Strength of Materials**
3-0-3. Prerequisites: MATH 2309, ESM 3301. Summer quarter. Shear centers for beams, analyses of stresses and deflections in unsymmetrical bending, stresses and deformations in curved flexural members, beams on elastic supports.

**ESM 6321. Applied Elasticity I**
3-0-3. Prerequisite: ESM 3301 or equivalent. Fall quarter. Analysis of stress and strain, stress-strain relations equilibrium, compatibility and boundary conditions, simple three-dimensional applications, plane elasticity problems in Cartesian and polar coordinates.

**ESM 6322. Applied Elasticity II**
3-0-3. Prerequisite: ESM 6321. Winter quarter. Continuation of Applied Elasticity I, torsion and flexure of bars, introduction to thermoelasticity, finite element, finite-difference approximations, and relaxation methods as applied to elasticity problems.

**ESM 6341. Theory of Elasticity I**
3-0-3. Prerequisites: ESM 3301 and MATH 2309, or consent of School. Fall quarter. Continuation of ESM 6341, linear elasticity, Saint-Venant's theory of torsion, bending of beams, Love's strain function, Galerkin's vector, Papkovitch-Neuber representation, stress potentials, Airy's stress function.

**ESM 6343. Theory of Elasticity III**
3-0-3. Prerequisite: ESM 6342 or consent of School. Spring quarter. Continuation of ESM 6342, variational formulation of elasticity, energy theorems, introduction to thermoelasticity, representation of biharmonic functions by analytic functions of a complex variable.
ESM 6361. Theory of Elastic Stability I
3-0-3. Prerequisites: ESM 3301 and MATH 4582, or consent of School. Winter quarter.
Various stability methods and their applicability, the elasto-plastic process, and bifurcation buckling. Stability of conservative systems, buckling of beams on elastic foundation, foundation buckling.

ESM 6362. Theory of Elastic Stability II
3-0-3. Prerequisite: ESM 6361 or consent of School. Spring quarter.
Stability of various systems—velocity dependent, conservative, dissipative, circulatory, and nonstationary, with examples of current development in elastic stability theory.

EMS 6371. Theory of Plates
3-0-3. Prerequisite: graduate standing and MATH 4582 or equivalent. Spring quarter.
von Karman theory of plates, pure bending of laterally loaded rectangular and circular plates, approximate methods, nonlinear considerations, stiffened and layered anisotropic plates.

ESM 6372. Theory of Shells
3-0-3. Prerequisite: ESM 6371 or consent of School. Fall quarter.
Stresses and deformations of shells with and without bending under various loading conditions, shells forming surfaces of revolution, hyperbolic paraboloidal and elliptic paraboloidal shells.

ESM 6381. Plasticity
3-0-3. Prerequisite: ESM 6321 or 6341, or consent of School. Spring quarter.
Stress-strain relations in three dimensions, three-dimensional yield conditions and flow laws, thick-walled tube and sphere, torsion of bars, slip line fields, dimension yield conditions and flow laws, thick-walled tube and sphere, torsion of bars, slip line fields.

ESM 6391. Finite Elasticity
3-0-3. Prerequisite: ESM 4351 or consent of School. Winter quarter.
Kinematics of finite deformation, stress, deformation and strain tensors, classical theory of finite elasticity for isotropic materials, introduction to simple materials.

ESM 6401-2. Optimization Techniques I and II
3-0-3 each. Prerequisite: graduate standing. Winter and spring quarters, even years.
Applications of calculus of variations to optimization of engineering systems and processes, end and corner conditions, discontinuous optimal processes, control and state variable inequality constraints, direct methods, etc.

ESM 6411. Energy Methods in Mechanics
3-0-3. Prerequisites: ESM 3301, MATH 4382 or consent of School. Summer quarter.
Virtual work, minimum total potential energy, minimum complementary energy, Castigliano's theorems, applications of calculus of variations, Rayleigh-Ritz method.

ESM 6450. Finite Elements, Boundary Elements, and Other Computational Methods in Mechanics I
3-0-3. Prerequisite: graduate standing in engineering. Fall quarter.
Introductory analytical methods, and stochastic process, the wave equation in a compressible fluid, radiation of sound, reflection, refraction, diffraction and scattering of sound waves, duct acoustics. Also listed as AE 6760-1-2 and ME 6760-1-2.

ESM 6763. Noise Reduction and Control (Industrial Applications)
3-0-3. Prerequisite: ESM 6760, ESM 4760 or equivalent. Spring quarter.
Methods of noise reduction and control applied to systems in industry. Measurement of sound power, material acoustic properties, barriers, enclosures, mufflers, vibration reduction and damping methods. Also taught as AE 6763, ME 6763.

ESM 6764. Ocean Acoustics
3-0-3. Prerequisite: GEOL 4300 or consent of School. Fall quarter. Spring quarter.
Propagation of sound waves in the oceans, stress-strain relationships, asymptotic ray theory. Propagation in shallow water and deep water. Also taught as AE 6764, GEOL 6764, ME 6764.

ESM 7000. Master's Thesis
3-0-3-3-4-5. Master's Report
1-0-1 respectively. Prerequisite: consent of adviser. Spring quarter.
A theoretical and/or experimental investigation in a major area of interest of an M.S. candidate. Written report must be approved by faculty adviser. Required of all M.S. students not doing a thesis.

ESM 7201. Mechanics of Composite Materials
3-0-3. Prerequisite: ESM 6371, ESM 6321 or 6341, or consent of instructor. Summer quarter.
Basic theory of anisotropic elasticity, equations for laminated composites, properties of laminates, estimation of the composite anisotropic moduli, bending, buckling and failure criteria of laminates.

ESM 7511. Analytical Fracture Mechanics
3-0-3. Prerequisite: ESM 6361, ESM 6372, or consent of School. Fall quarter.
The theory of viscoelasticity, simple fluids, viscometric flows and the determination of material functions.

ESM 7513. Stability of Shells
3-0-3. Prerequisites: ESM 6361, 6372. Fall quarter.
Linear and nonlinear theories for shell buckling, stability of thin stiffened and unstiffened plates and cylindrical shells under various loads, edge effects, imperfection sensitivity studies.

ESM 7515. Fluid Flow and Turbulence
3-0-3. Prerequisites: ESM 6361 and MATH 4382 or equivalent. Spring quarter.

ESM 7750. Biofluid Mechanics
3-0-3. Prerequisite: AE 6000 or ESM 6501, 6502 or consent of instructor. Summer quarter.
A unified treatment on hemorheology, hemodynamics, pulsed flow, microrheology, joint lubrication, pulmonary physiology, etc., with emphasis on quantitative approach. Also listed as AE 7750.

ESM 7999. Preparation for Doctoral Qualifying Examination
Credit to be arranged. Prerequisite: consent of adviser.

ESM 8001-2. Graduate Seminar
1-0-1 each.

ESM 8103-13-23-33-43-53. Special Topics
3-0-3-3-4-5. Special Topics
3-0-4-0 each. Prerequisite: consent of adviser. Spring quarter.
Special ad hoc courses not included in regular ESM graduate course offerings.

ESM 8104-14-24-34-44-54. Special Topics
4-0-4 each. Prerequisite: consent of adviser. Spring quarter.
Special ad hoc courses not included in regular ESM graduate course offerings.

ESM 8105-15-25-35-45-55. Special Topics
5-0-5 each. Prerequisite: consent of adviser. Spring quarter.
Special ad hoc courses not included in regular ESM graduate course offerings.

ESM 8501-2-3. Special Problems
Credit to be arranged. Prerequisite: consent of adviser. Individual study and analysis of problems of current and future interest in engineering and science.

ESM 8999. Doctoral Thesis Preparation
Credit to be arranged.
For student in preliminary stages of formulating doctoral research program who has not obtained formal approval of thesis topic.

ESM 9000. Doctoral Thesis

Curricula and Courses of Instruction
Suites. The study of industrial and systems engineering places emphasis upon developing the student's abilities to analyze and design systems that integrate technical, economic, and social behavioral factors in industrial, service, social, and government organizations. The degree program offered is the Bachelor of Industrial Engineering (B.I.E.).

**Bachelor of Industrial Engineering**

The principal strength of the program leading to the Bachelor of Industrial Engineering degree lies in a solid, well-coordinated core of courses in systems analysis and systems design, which relies heavily upon the engineering sciences, basic sciences, and social sciences. Elective hours make the program flexible as does the senior year design sequence, which permits a student to gain experience in design activities in manufacturing, service, health care, or government industries. The broad spectrum of required course work associated with the design sequence qualifies the student to perform in operations and facilities, management information and controls, and systems engineering environments. Technical and free electives may be used to satisfy requirements for the Health Systems Option under the B.I.E. curriculum.

**Options for Exceptional Students**

An option program is available to encourage students with superior abilities to participate in a range of unusual educational opportunities. Participation in these programs requires demonstrated scholastic excellence and prior arrangement with the student's adviser. The program includes the following options, individually or in combination.

**Graduate level courses in lieu of senior year electives**

Students with a cumulative grade-point average of 3.3 or above may schedule up to nine credit hours of approved graduate level courses. These credits, when approved by the student's adviser, may apply subsequently toward a graduate degree.

**Accelerated study**

Students with a 3.0 or above average during the preceding three quarters (including at least forty-five credits) may schedule up to twelve credits of project work, research work, or both. The student will perform this work, which may substitute for senior-year electives, in collaboration with the faculty or advanced graduate students. Students with less than a 3.0 average are limited to six credits of such project or research work.

**Individual project and research work**

Students with a 3.0 or above average during the preceding three quarters (including at least forty-five credits) may schedule up to twelve credits of project work, research work, or both. The student will perform this work, which may substitute for senior-year electives, in collaboration with the faculty or advanced graduate students. Students with less than a 3.0 average are limited to six credits of such project or research work.

**Governor's intern program**

ISYE seniors enrolled in the governor's intern program may receive six hours of design credit (4104-5) and six hours of ISYE elective credit for participation in the program.

**Visiting Scholar/Practitioner Offerings**

Occasionally, the School brings to campus selected individuals of unique accomplishment for course offerings built around their special areas of activity, thus making available a broader range of course materials than regularly provided. The typical schedule is Friday afternoon and evening instruction four times during the quarter.

**Program in Health Systems**

Health systems is the field of study and practice aimed toward improving the delivery of health care services through the application of systems science and management engineering. Programs emphasize systematic planning, engineering design, and scientific management in respect to health care facilities, manpower, and methods.

The program in Health Systems is an academic aspect of the School of Industrial and Systems Engineering and is affiliated with the Medical College of Georgia. The Program has education, research, and service components, and it engages in interdisciplinary and interinstitutional research, continuing education, and community outreach activities through the Health Systems Research Center.

Undergraduate preparation for this field is provided by a Health Systems Option under the B.I.E. degree curriculum. The undergraduate program prepares students for professional careers as health systems analysts and hospital management engineers.

**Graduate Programs**

The School of Industrial and Systems Engineering offers graduate programs leading to the degrees of Master of Science in Industrial Engineering, Master of Science in Operations Research, Master of Science in Statistics, Master of Science in Health Systems, and Doctor of Philosophy.

The M.S.I.E. program is available for students holding the B.I.E. degree and for other engineers who satisfy requisites covering the principal subject matter of the current B.I.E. curriculum. The M.S.O.R., M.S.S., and M.S.H.S. programs are available for students holding the B.S. in engineering, mathematics, or science. Requisites include work in probability, statistics, engineering economy, linear algebra, advanced calculus, and optimization, as well as selected application area work. The student must satisfy these requirements after enrollment; however, such course work may not apply toward fulfilling the degree requirements. The undesignated M.S. is intended for those...
students who desire to follow programs in systems analysis, industrialization, or other special areas. Except for the industrialization and systems analysis programs, a student has two options: either thirty-three-quarter hour courses work and a thesis or fifty-quarter hour courses of coursework and a thesis. The doctoral program requires forty-three-quarter hour courses of coursework and a thesis, and the systems analysis program requires thirty-three-quarter hour courses of coursework and a thesis.

The doctoral program is intended for highly gifted individuals for whom past accomplishments and evaluation indicate a high potential for successful completion of the program requirements, and a subsequent creative contribution to the field. Admission is, therefore, dependent upon student qualification rather than educational background in any specified discipline.

All degree curricula of the school are offered on a twelve-month basis. Students may begin graduate programs in any quarter.

Financial aid is available in the form of traineeships, fellowships, sponsored externships, and research and teaching assistantships.

Multidisciplinary Programs
See table on page 78.

Program in Statistics
The School of Industrial and Systems Engineering in the College of Engineering, the School of Mathematics in the College of Science and Liberal Studies, and the College of Management offer graduate work leading to the Master of Science in Statistics. The nature of this cooperative program emphasizes statistics as a science necessary in a technological environment such as that at Georgia Tech. Within this program, students can concentrate their studies on a specific area of application such as engineering, quality control, or management. Although this program can lead to further work towards a doctorate in statistics, it will primarily provide the background requisite for a professional career in statistics.

Career fields for graduates of this program may be found in virtually all areas of research, industry, and government. The program is designed to provide the graduate with competence to organize the collection, analysis, and interpretation of data reinforced by a sound understanding of statistical principles. Students will work with faculty actively engaged in research and prepared to teach the latest developments in statistics. By following either a thesis or non-thesis program, the student may complete the degree program in fifteen months. Students holding or anticipating an undergraduate degree from an accredited college or university in engineering, mathematics, science, or some other field that indicates a likelihood of successful completion of the program are encouraged to apply.

The program is administered by a committee appointed by the three schools. Currently the members of the committee are Harrison M. Wadsworth, Jr. (Industrial and Systems Engineering), chairman; M. Carl Spruill (Mathematics); and Fred E. Williams (Management). Interested students may obtain information regarding the program from any of these persons or from the associated schools.

The B.I.E. Curriculum

<table>
<thead>
<tr>
<th>Freshman Year Course</th>
<th>1st Q.</th>
<th>2nd Q.</th>
<th>3rd Q.</th>
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<tbody>
<tr>
<td>ENGL 1001-2 Analysis of Literature and Language</td>
<td>3-0-3</td>
<td>3-0-3</td>
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<tr>
<td>CHEM 1101-2 General Chemistry</td>
<td>4-3-5</td>
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<tr>
<td>MATH 1307-8 Calculus I, II, III</td>
<td>5-0-5</td>
<td>5-0-5</td>
<td>5-0-5</td>
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<tr>
<td>EGR 1170 Visual Communication and Engineering Design</td>
<td>2-3-3</td>
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<tr>
<td>ICS 1400 Introduction to Algorithms and Computing</td>
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<td>ICS 1700 Digital Computer Organizational Programming</td>
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<tr>
<td>PHYS 2122 Electromagnetism</td>
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<tr>
<td>PHYS 2123 Optics and Modern Physics</td>
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<td>4-3-5</td>
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<tr>
<td>ECON 2000-1 Principles of Economics I, II</td>
<td>3-0-3</td>
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<td>MGT 2000-1 Accounting I, II</td>
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<tr>
<td>ESM 2201 Statics</td>
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<tr>
<td>MATH 2307-8 Calculus IV, V</td>
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<tr>
<td>MATH 3709 Math for Systems Engineering</td>
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<tr>
<td>ISYE 3025 Engineering Economy</td>
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<td>ISYE 3027 Applications of Probability</td>
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<td>PSY 3003 General Psychology I</td>
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<tr>
<td>Elective Social Science</td>
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<td>3-0-3</td>
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<td>Elective Humanities</td>
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<td>Totals</td>
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Junior Year Course

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<th>1st Q.</th>
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<th>3rd Q.</th>
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<tr>
<td>ESM 3201 Dynamics I</td>
<td>3-0-3</td>
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Curricula and Courses of Instruction

Industrial and Systems Engineering
Health Systems Option

Industrial engineering undergraduates who wish to prepare themselves for practicing their profession in the rapidly expanding health industry may do so by enrolling in the Health Systems Option under the B.I.E. curriculum.

Health care is humanitarian, and health services are important to society; the industry is large, diverse, and in need of improvement. This specialty field is an opportunity to use modern scientific methods in the performance of a vital public service. The required health orientation is provided by a series of courses and project work, utilizing electives in the B.I.E. curriculum, as follows:

Certificate in Health Systems

Students who successfully complete the Health Systems Option and other degree requirements will be awarded both the Bachelor of Industrial Engineering degree and a Certificate in Health Systems. These credentials signify competence to practice industrial engineering in the health industry.

Students completing requirements for other bachelor's degrees will also be awarded a Certificate in Health Systems if their transcripts include credit for the following courses: HS 3001, 3011, 4115, 4116, ISYE 3010, 3025, 3029, 3125, 4101, 4102, 4103, 4104, 4105, and a three-hour approved elective.

Students enrolled in the Health Systems Option must complete HS 3001, 3011, 4115, and 4116 to satisfy the B.I.E. requirement of twelve hours of approved technical electives. The ISYE 4104-5 sequence is an individually tailored, computer-based, Management Systems course.

Human Health Systems Option

Further topics in modeling and methods for optimization. Includes advanced algorithms for linear programming, integer programming methods and applications, nonlinear programming, and dynamic programming. Introduction to classical/modern system analysis and feedback dynamics as applied to industrial engineering problems. Transfer functions, state models, transient and steady state behavior, stability, and compensation.

Courses of Instruction

INDUSTRIAL AND SYSTEMS ENGINEERING

ISYE 3010. Man-Machine Systems
3-0-3. Prerequisites: ISYE 3028, PSY 3303.
Human factors engineering and mathematical modeling of human-machine interaction in complex systems such as computers, aircraft, power generation, and process control. Emphasis on human perceptual and cognitive abilities related to interfaces.

ISYE 3014. Systems and Productivity
3-0-3. Prerequisite: ISYE 3105.
Human contributions to productivity and interaction of technical advances with human performance. Examination of impact of individual needs, leadership styles, and organizational design on productivity.

ISYE 3025. Engineering Economy
3-0-3. Prerequisite: MGT 2000 or equivalent. Limited to ISYE and HS students.
Methods of economic analysis in engineering including decision problems, value measurement, interest relationships, criteria for decisions under certainty, risk, and uncertainty.

ISYE 3027. Applications of Probability
3-0-3. Prerequisite: MATH 1309.
Introduction to probability, emphasizing applications in science and engineering. Topics include probability concepts, random variables, discrete and continuous distributions.

ISYE 3028. Engineering Statistics I
3-0-3. Prerequisite: ICS 1400 or 1700, or equivalent.
Introduction to standard methodology, emphasizing applications in science and engineering. Topics include estimation, hypothesis testing, and process control.

ISYE 3029. Engineering Statistics II
3-0-3. Prerequisite: ISYE 3028 or equivalent.
Introduction to analysis of planned and unplanned experiments. Topics include regression and analysis of variance with applications to problems in engineering and science.

ISYE 3100. The Professional Practice of Industrial and Systems Engineering
3-0-3. Prerequisite: junior standing.
A laboratory seminar wherein students meet industrial and systems engineering practitioners to discuss their current work problems and career progression.

ISYE 3105. Organizational Structures
3-0-3. The organizational elements, activities, and structures within which an industrial engineering function.

ISYE 3113. Physiological and Biomechanical Analysis of Work
3-0-3. Prerequisite: ISYE 3105.
Theoretical and practical data collection and analysis for effective manual- and tool-oriented work and workplace design.

ISYE 3215. Design and Measurement of Work Methods
3-0-3. Corequisite: ISYE 3209.
Introduction to principles and techniques for analysis, design, and measurement of work methods.

ISYE 3231. Deterministic Operations Research
3-0-3. Prerequisites: Math 2307 and ISYE 3100 or 1700.
Deterministic models and methods of operations research in solving engineering and management problems. Topics include linear models, linear programming, duality, post optimality analysis, and network analysis.

ISYE 3232. Probabilistic Operations Research
3-0-3. Prerequisite: ISYE 3207, 3231, or equivalent.
Stochastic models and methods of operations research in solving engineering and management problems. Includes queuing theory, decision models, inventory models, Markov decision processes, and decision analysis under risk.

ISYE 3333. Advanced Operations Research
3-0-3. Prerequisite: ISYE 3232.
Further topics in modeling and methods for optimization. Includes advanced algorithms for linear programming, integer programming methods and applications, nonlinear programming, and dynamic programming.

ISYE 3260. Introduction to Systems Engineering
3-0-3. Prerequisite: MATH 1309.
Introduction to classical/modern system analysis and feedback dynamics as applied to industrial engineering problems. Transfer functions, state models, transient and steady state behavior, stability, and compensation.

ISYE 4000. Introduction to Systems Theory
3-0-3. Prerequisite: consent of School.
The basic classical and modern concepts and tools required for modeling, analysis and synthesis of linear, discrete and continuous, deterministic and dynamic systems.

ISYE 4005. Nonlinear Programming
3-0-3. Prerequisite: ISYE 3233 or equivalent.
Solution procedures for nonlinear programs. Unconstrained optimization, gradient and gradient-free methods, constrained optimization, Lagrange multipliers, penalty functions, and linear approximation methods.

ISYE 4006. Integer and Dynamic Programming
3-0-3. Prerequisite: ISYE 3233 or equivalent.
Optimization by dynamic and integer programming. Decision trees, optimality principle, and recursive relationships. Optimization in integer by cutting planes, branch and bound and implicit enumeration.

ISYE 4022. Job Evaluation and Wage Incentives
3-0-3. Prerequisite: ISYE 3215.
Study of principles used to establish wage rates and salaries. Emphasizes characteristics and objectives of wage incentive plans and design and analysis of incentive formulas.

ISYE 4024. Fundamentals of Materials Handling
3-0-3. Prerequisites: ISYE 3025, 4102.
Development of procedures and techniques for analysis and solution of materials handling problems. Plant trips and laboratory utilized to illustrate modern materials handling methods.
ISYE 4028. Introduction to Feedback Dynamics 2-3-3.
Examination of feedback processes as causes of dynamic behavior in socioeconomic and managerial systems. Emphasizes feedback loop performance characteristics and computer simulation of multivariate nonlinear systems.

ISYE 4035. Project Management Systems Design 2-3-3. Prerequisites: ISYE 3211 and senior standing or consent of School.
Project planning and control using activity network analysis. Emphasizes network logic, scheduling computations, resource scheduling, time cost trade-off algorithms and multiproject resource allocation.

ISYE 4039. Quality Control 3-0-3. Prerequisite: ISYE 3028 or equivalent.
Design of quality control systems. Quantitative techniques for establishing product specifications, process controls, acceptance inspection, and other techniques of quality assurance.

ISYE 4044. Simulation 2-3-3. Prerequisites: ISYE 3028, 3232.
Discrete simulation methodology emphasizing statistical basis for simulation modeling and modeling and experimentation. Overview of computer languages and continuous flow models. Laboratory exercises illustrating model architecture, inference, and optimization.

ISYE 4073. Storage and Distribution Systems Design 3-0-3. Prerequisite: ISYE 4102.
Fundamentals of designing efficient materials and product distribution systems emphasizing warehouse planning, materials and information flow, equipment selection, building design and location, automated warehousing and transportation.

ISYE 4090. Legal and Ethical Issues of Business 3-0-3. Prerequisite: senior standing or consent of School.
Introduces the engineer to the ethical, legal, and professional attributes to be encountered in the future working environment. Includes business, patent, and professional attitudes to be encountered in the future working environment. Includes business, patent, and professional attitudes to be encountered in the future working environment.

ISYE 4101. Operations Planning and Scheduling 3-3-4. Prerequisites: ISYE 3211, 3232.
Analytical methods for production and inventory control emphasizing forecasting techniques, inventory models, application of mathematical programming and network models, sequencing and scheduling techniques and line balancing.

ISYE 4102. Operations and Facilities Design 3-3-4. Prerequisites: ISYE 3219, 3232.
Principles and practices in the design of operations and facilities for a productive system.

Principles of the analysis and design of management information and control systems—especially those involving electronic data processing.

ISYE 4104. ISYE Design I 0-9-3. Prerequisites: ISYE 4101, 4044, 4102. Must be followed by ISYE 4105 in consecutive quarters. Limited to ISYE students.
Senior ISYE group design project requiring problem definition and analysis, synthesis, specification, and installation of a designed solution in off-campus enterprise environments.

ISYE 4105. ISYE Design II 0-9-3. Prerequisites: ISYE 4103, 4104. Limited to ISYE students.
Senior continuation of ISYE group design project sequence (ISYE 4104) requiring problem definition and analysis, and synthesis, specification, and installation of a designed solution.

ISYE 4145. Simulation Applications 2-3-3. Prerequisite: ISYE 4044.
Continuation and extension of ISYE 4044. Discrete-event simulation methodology with emphasis on analysis of systems and models. Input data analysis, validation, output analysis, inference, comparison of systems, optimization of systems. Advanced modeling techniques in a computer simulation language such as GPSS.

Fundamental principles and basic techniques of economic analysis of engineering projects including economic measures of effectiveness, time value of money, cost estimation, break-even and replacement analysis.

ISYE 4756. Technological Forecasting 3-0-3. Prerequisite: senior standing or consent of School.

ISYE 4757. Technology Assessment 3-0-3. Prerequisite: senior standing.
Systematic efforts to anticipate impacts on society that may occur when a technology is introduced, extended, or modified. Considered concepts, organization, and uses of various specific assessment methods.

Courses in special topics of timely interest to the profession conducted by resident or visiting faculty.

Credit to be arranged. Prerequisite: senior standing in ISYE and prior faculty topic approval. A one- to-three-hour credit opportunity to develop initiative and apply fundamental principles by performing semigittal laboratory or research work in industrial and systems engineering.
An introductory course in inventory theory. Deterministic lot size models, probabilistic models of continuous and periodic review policies, dynamic models, and multichelon systems.

**ISYE 6307. Scheduling Theory**  
3-0-3. Prerequisite: ISYE 6650.  
Analysis of sequencing and scheduling activities. Static scheduling problems, dynamic scheduling systems, simulation studies of priority dispatching rules. Priority queuing models.

**ISYE 6308. Analysis of Production of Operations**  
3-0-3. Prerequisites: ISYE 6306, 6669.  
Mathematical models for production planning, applications of mathematical programming, dynamic programming, network theory, and heuristic methods to problems of planning production, inventories, and capacity.

**ISYE 6400. Design of Experiments I**  
3-0-3. Prerequisite: ISYE 6739 or equivalent.  
Analysis and application of standard experimental designs, including factorialized, randomized block, Latin squares, confounding and fractional replication multiple comparisons, and an introduction to response surfaces.

**ISYE 6401. Applied Regression Analysis I**  
3-0-3. Prerequisite: ISYE 3028 or ISYE 6739 or equivalent.  
Analysis of data from unplanned experiments. Emphasis on the application of statistical principles to empirical model building.

**ISYE 6402. Time Series Analysis**  
3-0-3. Prerequisite: ISYE 3231 or equivalent.  
Building empirical-stochastic models of the autoregressive moving average form for stationary and nonstationary phenomena. Topics include identification procedures, parameter estimation, diagnostics checking, and model forecasting.  
Text: at the level of Box and Jenkins, *Time Series Analysis, Forecasting and Control*.

**ISYE 6404. Nonparametric Statistics**  
3-0-3. Prerequisite: ISYE 6739 or equivalent.  
Basic concepts and applications of nonparametric statistics. Order statistics, runs, goodness of fit tests, one-sample, two-sample, and K-sample tests for location and scale.

**ISYE 6405. Response Surfaces I**  
3-0-3. Prerequisite: ISYE 6400.  
Introduction to response surface methodology. Topics include canonical analysis, steepest ascent, first and second order response surface designs, concepts of rotatable and uniform precision designs, orthogonal blocking.  
Text: at the level of Myers, *Response Surface Methodology*.

**ISYE 6406. Response Surfaces II**  
3-0-3. Prerequisite: ISYE 6405.  
A continuation of ISYE 6405. Topics include optimal designs for fitting polynomials, experiments with mixtures, multiple response problems, mechanistic model building, and sequential designs.

**ISYE 6407. Sampling Techniques**  
3-0-3. Prerequisite: ISYE 3029 or equivalent.  
Survey sampling techniques. Topics include simple random and stratified random sampling, ratio estimation, regression techniques, systematic, cluster and multistage, sampling, and sources of error.  

**ISYE 6427. Applied Statistical Decision Theory**  
3-0-3. Prerequisite: MATH 4241 or equivalent.  
An intermediate-level course in statistical decision theory and its application to problems in generations research, industrial, and systems engineering.  
Text: at the level of Raiffa and Schlaifer, *Applied Statistical Decision Theory*.

**ISYE 6515. Analysis of Distribution Systems**  
3-0-3. Prerequisite: ISYE 4044, 4101, or equivalent.  
Study of the various types of transportation systems available to enterprises for distributive services. Analysis of distribution alternatives stressed, emphasizing design of economic and control systems encountered.

**ISYE 6524. Material Flow Systems**  
3-0-3. Prerequisite: ISYE 4101-2 or consent of School.  
Methodology useful in the analysis and design of plant material flow systems and their interfaces with transportation and distribution systems emphasizing quantitative and simulation techniques.  
Text: at the level of Ross, *Introduction to Probability Models*, 2nd ed.

**ISYE 6650. Probabilistic Models in Operations Research**  
3-0-3. Prerequisite: ISYE 3027 or equivalent.  
Text: at the level of Ross, *Introduction to Probability Models*, 2nd ed.

**ISYE 6656. Queuing Theory**  
3-0-3. Prerequisite: ISYE 6650.  
Text: at the level of Cooper, *Introduction to Queuing Theory*.

**ISYE 6669. Linear Deterministic Models in Operations Research**  
4-0-4. Prerequisite: ISYE 3231 or equivalent.  
The optimization of linear models including the revised, dual, and primal simplex methods, duality theory, decomposition, cutting plane algorithms, some network algorithms.

**ISYE 6670. Nonlinear Deterministic Models in Operations Research**  
4-0-4. Prerequisite: ISYE 3231 or equivalent.  
Algorithms for solving nonlinear constrained and unconstrained problems at the level of Aoki, *Introduction to Optimization Techniques*, Quadratic programming, dynamic programming, and enumerative methods.

**ISYE 6671. Discrete Deterministic Models in Operations Research**  
3-0-3. Prerequisite: ISYE 6734 or equivalent.  
The optimization of discrete deterministic models including general enumerative methods and special algorithms for well-known discrete problems on graphs and networks.

**ISYE 6769. Computational Methods in Optimization**  
3-0-3. Prerequisites: ISYE 6600 and knowledge of FORTRAN.  
Strategies and techniques for translating optimization theory into effective computational software. Emphasis on applications in linear, nonlinear, and integer programming, networks, and graphs.

**ISYE 6780. Location Theory**  
3-0-3. Prerequisite: ISYE 6609 or consent of School.  
Applications of optimization theory to the location of facilities. Area and point location problems in discrete and continuous space are examined. Private and public sector applications are considered.

**ISYE 6734. Methods of Operations Research**  
5-0-5. Prerequisite: MATH 2309. Corequisite: statistics.  
An introduction to the methods for analytical formulation and solution of decision problems. Mathematical methods of optimization and classical operations research models are introduced. Not available for degree credit to ISYE students.

**ISYE 6739. Experimental Statistics**  
4-0-4. Prerequisite: MATH 2308.  
An introduction to the application of statistics. Topics include probability concepts, sampling distributions, point and interval estimation, hypothesis testing, multiple linear regression, analysis of variance. Not available for degree credit to ISYE students.  

**ISYE 6751-2. Complex Systems Design I, II**  
2-3-3. Prerequisites: ISYE 4044, ISYE 6400.  
A complex systems design course with emphasis on model building and the design and analysis of simulation experiments for complex systems.

**ISYE 6841. Decision Support Systems**  
2-3-3. Prerequisites: ISYE 6734 or equivalent, ISYE 6739 or equivalent.  
Interactive computer support of design, analysis, and decision making. Hands-on project in decision-aiding system development. APL programming language.  
Text: at the level of Master's Thesis.  
Prerequisite: ISYE 6734 or equivalent.  
A continuation of experimental design stressing fractional factorial designs, analysis of unbalanced data, and covariance models. Topics include confounding and
fractional designs, incomplete blocks, general methods for the analysis of unbalanced data, and covariance analysis.

ISYE 7401. Applied Regression Analysis II 3-0-3. Prerequisite: ISYE 6401. A continuation of the concepts of multiple regression analysis begun in ISYE 6401. Topics include multiple-linearity diagnostics, biased estimation, detection of high leverage observations, robust fitting, and an introduction to nonlinear regression.

ISYE 7441. Linear Statistical Models I 3-0-3. Prerequisites: MATH 4241 and ISYE 6400. Introduction to full rank linear statistical models, including least squares and maximum likelihood estimation, interval estimation, and hypothesis testing. Regression models are discussed.

Text: at the level of Graybill, *Linear Statistical Models*.

ISYE 7442. Linear Statistical Models II 3-0-3. Prerequisite: ISYE 7441. A continuation of ISYE 7441 emphasizing linear statistical models of less than full rank. Balanced designs, including fixed, mixed, and random models, are stressed.

Text: at the level of Graybill, *Linear Statistical Models*.

ISYE 7656. Advanced Queuing Theory 3-0-3. Prerequisite: ISYE 6636. Topics include imbedded Markov chain queuing models, waiting times under various queue disciplines, and current research problems.


Text: at the level of Mangasarian, *Nonlinear Programming*.

ISYE 7672. Optimization: Adjacent Extreme Point Methods 3-0-3. Prerequisite: ISYE 6669. A study of current literature in adjacent extreme point methods including quasi-concave recent duality results, complementary pivot theory, quadratic and stochastic programming.


ISYE 7674. Dynamic Programming 3-0-3. Prerequisite: ISYE 6669 or equivalent. Advanced treatment of the elements of modern dynamic programming via the state space formalism.

Problem formulation, computational aspects, and dimensionality reduction. Application to various fields.

ISYE 7675. Network Flows 3-0-3. Prerequisite: ISYE 6669. Introduction to networks including characterization theorems and algorithms for flow problems, flow with gains, multicommodity flows, disconnecting sets, and matching theory.

ISYE 7676. Combinatorial Optimization 3-0-3. Prerequisite: ISYE 6669 or consent of instructor. Principal topics include independent sets and cliques in graphs, graph coloring, trees and circuits, planarity, and matching. Some complexity issues are covered as well as worst-case performance for efficient heuristics.

ISYE 7677. Integer Programming 3-0-3. Prerequisite: ISYE 6669. The methods and applications of integer programming including cutting plane methods, implicit enumeration, heuristic techniques, group theoretic and other developments.

ISYE 7678. Decomposition Methods for Large Systems 3-0-3. Prerequisite: ISYE 6669. Solution strategies, illustrated with examples, for handling complex systems with large numbers of variables and/or restrictions, linear and nonlinear.

ISYE 7680. Advanced Location Theory 3-0-3. Prerequisite: ISYE 6670, 6680, or consent of School. Theoretical aspects of location problems are emphasized, drawing upon results from linear and nonlinear programming, graph theory, and network analysis. Recent research literature is covered.

ISYE 8011-12-13. Seminar 1-0-1 each. Audit basis only.

ISYE 8100-1-2. Special Topics 3-0-3 each. Prerequisite: consent of School. Special topic offerings not included in regular courses.

ISYE 8561-2-3. Seminar in Operations Research Credit to be arranged. Prerequisite: consent of School. Topics within the area of operations research which are of a special interest to the faculty and graduate students and which are not included in regularly offered courses.

ISYE 8601-2. Projects in Operations Research Credit to be arranged. Prerequisite: consent of School. This course provides, through project work, experience in the application of operations research methods to real-world systems.

ISYE 8704-5-6. Special Problems in Industrial Engineering Credit to be arranged. Prerequisite: consent of School.

ISYE 9000. Doctoral Thesis Credit to be arranged. Prerequisite: consent of School.

HEALTH SYSTEMS

HS 3001. Introduction to Health Systems 3-0-3. Prerequisite: none. Historical background; nature, problems, and costs of health care institutions; health resource planning, finance, health care policy, role of government; methods, improvement and management engineering.

HS 3011. Hospital Functions 3-0-3. Internal structure, functions, and management problems of hospitals, including departmental interactions, hospital and medical terminology, process flows of materials, supplies, personnel, patients, paperwork, and information.

HS 3221. Health Information Systems 3-0-3. Prerequisites: HS 3001 or 3011. ICS 1700, MGT 2000. Hospital and medical information systems, data collection, storage, processing and reporting, file design, record structure, processing requirements, controls, report formats, medical records, and statistical audits.


HS 3341. Health Systems Planning 3-0-3. Prerequisite: HS 3001 or 3011. The systems approach to health planning, policy and program decisions, functional systems specifications, recycling for compromise, systems integration, facility and manpower requirements.

HS 4115. Health Field Applications I 3-0-3. Prerequisites: HS 3001 and ISYE 3215. Establishing and operating a hospital management engineering program; applications of methods engineering, work measurement, sampling, job evaluation, and incentives to hospital management systems problems.

HS 4116. Health Field Applications II 3-0-3. Prerequisites: HS 3001 or 3011, ISYE 3025, 3026, 3231. Applications of industrial engineering, operations research, and other quantitative methods to hospital management systems problems. Techniques include statistics, forecasting, managerial control, queuing, simulation, economic analysis, and optimization.

HS 6001. Introduction to Health Systems 3-0-3. Description of the health care system and its interactive resource components, with emphasis upon accessibility, availability, distribution, and cost. Health systems inputs, processes, and outputs.


HS 6116. Health Systems Applications II 3-0-3. Prerequisites: HS 6001, ISYE 3028, 3215. Applications of operations research and other quantitative methods to hospital management problems. Forecasting, managerial control, waiting lines, facility planning, resource allocation, and information systems.

HS 6117. Health Systems Applications III 3-0-3. Prerequisites: HS 6001, ISYE 3025, MGT 6000. Applications of economics, engineering economy, and cost accounting to hospital management problems. Case-mix methodologies, budgeting, revenue enhancement, cost containment, and governmental regulation.

HS 6231. Project Management 3-0-3. Principles and techniques of managing a health systems service program; project planning, direction, and control; dealing with environmental subtleties; management reporting and project implementation.

HS 6341. Health Systems Planning 3-0-3. Prerequisites: HS 6001, ISYE 3028. Planning for health care needs of a community as a system. Analysis of community structure, policy making, planner-community interactions, accessibility barriers to services.


HS 6571-2-3-4-5-6. Graduate Field Training 0-3-1 through 0-18-6. Prerequisite: HS 6351. Open to HS students only. Field training for individual graduate students in relation to health care institutions, health service organizations, or health planning agencies. Graduate project, formal written report, and oral presentation. Normally passed only over two or three quarters.

HS 6665. Graduate Case Studies 3-0-3. Prerequisites: HS 6001, 6115, 6116. Applications of hospital management engineering and health systems planning techniques using examples drawn from professional practice and research reported in the literature.

HS 7000. Master's Thesis Prerequisite: prior arrangement with School.
General Information
The School of Materials Engineering was established on March 1, 1985, to provide increased focus for research and instruction on materials at Georgia Tech. The School comprises two components: the Ceramic Engineering Program and the Metallurgical Engineering Program. Each of these two programs is described in the following sections.

Ceramic Engineering Program
In the United States, the ceramic industry annually produces over $40 billion worth of products ranging from brick, tile, glass, portland cement, and dinnerware to high-temperature refractories for furnace linings, abrasives, and many sophisticated electronic components. While traditional products create a continuing demand for trained personnel, the development of new products constantly opens fresh career opportunities. Some examples of these new products from the recent past include rocket nozzles, jet engine parts, electronic circuitry for computers, and fiberglass products for nose cones and missiles. Current developments include automotive exhaust catalyst supports and other pollution control devices, new lighting techniques, and electro-optical materials.

Ceramic engineering applies sound, scientific engineering principles to solve manufacturing problems in the industry. Because both chemical and physical reactions occur at the high temperatures used in ceramics manufacturing, the problems frequently become more complex and challenging. Measurements are difficult, and economical production imposes cost constraints.

The School of Ceramic Engineering offers a four-year curriculum leading to the bachelor's degree and graduate work leading to the master's degree and graduate work leading to the doctorate degree. The undergraduate curriculum prepares the degree candidate for a position in the ceramic industry or for graduate work. Additional courses introduce non-majors to ceramic materials, processes, and applications.

School of Materials Engineering
Established in 1985
Acting Director—Gary Poehlein

Ceramic Engineering Faculty
Professors—James F. Benzela, A. T. Chapmana, Willis E. Moody, Joseph L. Pentecost; Associate Professor—Joe K. Cochran, Jr.; Research Engineer—David N. Hill; Lecturer—A. Y. Young.

Metallurgical Engineering Faculty
Professor and Head—Stephen D. Antolovich; Professors—Helen E. Grengaa, Robert F. Hochman, Ashok Saxena, Ervin E. Underwood; Associate Professors—Miroslav Marek, Pieter Muije; Assistant Professor—Stuart R. Stock; Adjunct Professors—Henry Chia, Bruce G. Lefevre.

Fracture and Fatigue Research Laboratory
Director—Stephen D. Antolovich
The field of metallurgy is a vital component of the industrial economy because of its central contribution to the selection and use of metals in all engineering and scientific fields. The program at Tech offers a master's degree in metallurgy and a doctoral degree. An excellent selection of undergraduate courses is offered in preparation and support of graduate studies. Course offerings and research activities cover a range of subject areas in the broad field of metallurgy. Subjects include chemical and extractive metallurgy, corrosion science and engineering, physical metallurgy, mechanical metallurgy, and metallurgical processing and mineral engineering.

Undergraduates desiring to specialize in metallurgy can pursue an undesignated degree program which is equivalent to Accreditation Board for Engineering and Technology (ABET) requirements for an accredited degree at any other school.

Research facilities are among the program's strongest features. Excellent general corrosion laboratory equipment is part of the corrosion research facilities in which hydrogen embrittlement, metal dusting, stress-corrosion-cracking, and mechanical and dental material investigations are carried out. Structural investigations of metals and alloys are performed in the x-ray laboratory having a variety of general equipment and in the electron microscopy laboratories. These labs house a Siemens research electron microscope and the newly acquired TEM-100C scanning transmission electron microscope, which is the most advanced equipment in the field. Metallographic equipment, heat treatment furnaces, and alloy-melting equipment allow investigators to design and produce new materials. Mechanical testing facilities include both standard and specialized equipment, most notably the MTS universal mechanical testing equipment now being used for fatigue research in a range of alloys.

Graduates find employment with manufacturing firms in light and heavy industry and in research laboratories of private firms and federal agencies. Several recent graduates have filled positions of high responsibility in the Atlanta area and have been instrumental in advancing the level of materials engineering practice in Georgia.

The Metallurgy Program faculty participate in several multidisciplinary programs, including materials engineering, mineral engineering, and manufacturing engineering, and in the interdisciplinary program in surface science technology.

### Fracture and Fatigue Research Laboratory

The Fracture and Fatigue Research Laboratory (FFRL) was established to encourage interdisciplinary research and educational opportunities in the field of fracture and fatigue of materials. Faculty members representing various academic departments of Georgia Tech, as well as staff members of the Georgia Tech Research Institute (GTRI), are involved in its activities. The research programs, which focus on the fracture and fatigue behavior of engineering materials, are interdisciplinary and based on a combined fracture mechanics-materials science point of view. Projects involving the behavior of metals, ceramics, polymers, and composites all fall within the scope of the laboratory.

Graduate students participating in FFRL research usually enroll for the master's or doctoral degree in the traditional discipline of their choice. However, they pursue course work related to a broader understanding of materials and benefit from the association with other students and faculty in the interdisciplinary setting. Students with backgrounds in materials science, metallurgy, ceramics, chemistry, physics, or any branch of engineering are encouraged to apply.

### The Master's Degree

The program in metallurgy offers graduate work leading to the degree of Master of Science in Metallurgy. The student admitted for graduate work will normally have completed an undergraduate program in metallurgy or metallurgical engineering. However, students with undergraduate degrees or backgrounds in other fields (e.g., physics, chemistry, geology, and chemical, ceramic, mechanical, nuclear, or geological engineering) may qualify by taking certain minimum prerequisites during the early part of their graduate studies. To assure a smooth transition into the graduate Metallurgy Program, the student should select appropriate electives during his or her undergraduate studies.

The Master of Science in Metallurgy curriculum offers two options: (1) physical metallurgy and (2) chemical metallurgy. Both have a common core of basic studies but differ in other aspects. Specialization in one of these areas does not alter the Master of Science degree. The student must prepare the individualized program of study for this degree in conference with his or her graduate adviser. The proposed program must receive the approval of the graduate adviser and the director and will include a thesis.

### Physical Metallurgy

This option deals with the relationships between chemical composition, structure, and properties of metals and alloys. Activities of the physical metallurgist include the study of atomic structure of solids, alloy development, and the mechanical, physical, and corrosion behavior of metals and alloys in engineering applications.

### Chemical Metallurgy

This option deals with the concentration of minerals from natural resources and the extraction of pure metal from these concentrates. Recycling of metal scrap and other waste products is also a specialty of the chemical metallurgist. The industries that usually require the services of the chemical metallurgist are iron, steel, aluminum, copper, and other basic metal producers. In addition, the chemical metallurgy option deals with the fundamental characteristics of metal and alloy deterioration (corrosion) and the properties and structures of metal surfaces (surface science) in liquid and gas environments.
The Doctoral Degree
The Doctor of Philosophy degree is directed toward the goal of attaining proficiency in the conduct of independent scholarly work. The degree program comprises course work in the principles of metallurgy, additional specialized courses both in the area of the doctoral thesis and in one or two other areas, demonstration of reading competence in a foreign language, the passing of a comprehensive examination, and an independent research investigation.

Except for the requirement that the student must earn fifteen credit hours in a minor field, which may be any technical or non-technical field that he or she chooses, there are no definite course requirements for the doctoral degree in metallurgy. Most students find that they will schedule about sixty to seventy hours of courses. Students should commence participation in the departmental research programs early in their graduate careers. The undertaking of a doctoral thesis is usually reserved until the candidacy examination is passed, usually the second graduate year for a well-prepared student.

Financial Aid
A number of fellowships and research assistantships from outside sources and industry are available to provide financial assistance for qualified graduate students. In addition, a limited number of Presidential Fellowships, as well as teaching and research assistantships, are available from the Institute. Waiver of out-of-state tuition is possible for qualified students. Further information can be obtained by writing the director of the School of Materials Engineering.

Courses of Instruction

CERAMICS ENGINEERING

CERE 1010. Introduction to Ceramic Engineering
2-3-3. Elective for freshmen.
A comprehensive survey of ceramic materials, raw materials, and the industrial processes used in their production.
Text: at the level of Mitchell, Ceramics—Stone Age to Space Age.

CERE 3002. Properties of Engineering Materials
2-3-3. Prerequisite: CHEM 1101 or equivalent.
Introduction to types of materials available to engineers, their properties, the causes of these properties, and how these properties determine their utilities and service life.
Text: at the level of Van Vlack, Elements of Materials Science; Kingery, Introduction to Ceramics.

CERE 3003. Ceramic Processing I
2-3-3. Prerequisite: CHEM 1102 or equivalent.
The processing of ceramic materials for use in plastic forming processes is studied. The principal plastic-forming processes are covered in detail.
Text: at the level of Jones, Ceramics, Industrial Processing, and Testing; Norton, Elements of Ceramics.

CERE 3004. Ceramic Processing II
2-3-3. Prerequisite: CERE 3003 or consent of School.
The production, processing, and analysis of small particle-size, high surface area ceramic powders are reviewed. Use of such powders in non- plastic forming processes is studied.
Text: at the level of Wang, Ceramic Fabrication Processes.

CERE 3006. Physical Ceramics I
3-0-3. Prerequisite: CERE 3002.
Crystal chemistry concepts are developed and used to characterize silicate, oxide, and nonoxide ceramic materials.
Text: at the level of Kingery, Introduction to Ceramics.

CERE 3007. Pyrometry and Thermal Analysis
2-3-3. Prerequisite: PHYS 2122.
Temperature measurement using thermocouples, optical pyrometers, and radiation pyrometers is emphasized. Differential thermal analysis and thermogravimetric analysis in characterizing ceramic materials is presented.
Text: at the level of Precision Measurement and Calibration, volume two; Temperature, NBS Special Publication 500.

CERE 3008. Glass Technology I
3-0-3. Prerequisite: CERE 3105 or consent of School.
The fundamentals of glass structure, composition, manufacturing, properties, and applications are described. In the laboratory many glass batches are melted and analyzed.

CERE 3080. Survey of Ceramics
2-0-2.
General elective for non-majors. A survey of the classifications and physical properties of ceramic products, the materials, and manufacturing processes.
Text: at the level of Mitchell, Ceramics—Stone Age to Space Age.

CERE 3090. Ceramic Survey Laboratory
0-3-1. Prerequisite or corequisite: CERE 3080.
General elective. Plant trips to local ceramic plants, flow sheets of processes, production of simple pottery and ceramic pieces.

CERE 3101. Ceramic Data Handling
3-3-4.
Study of testing, rational economic value of test results, basis of test selection, interpretation of results, data analysis, statistical methods, computer methods, of testing.

CERE 3105. Ceramic Phase Equilibria
2-3-3. Prerequisite: CHEM 1102 or equivalent.
Interpretation of phase equilibria in nonmetallic one-, two-, and three-component systems. Use of phase diagrams in the processing of ceramic materials is discussed.

CERE 4003. Physical Ceramics II
2-3-3. Prerequisites: CERE 3006, PHYS 2123, CHEM 3413.
Densification sintering and reaction kinetics active in ceramic materials are considered. The resultant physical, mechanical, electric, and magnetic properties are related to the atomic and macroscopic structure representative of ceramic products.
Text: at the level of Kingery, Introduction to Ceramics.

CERE 4004. High Temperature Thermodynamics
2-0-2. Prerequisite: CHEM 3412.
Chemical thermodynamics data is used to produce reaction directions and study vaporization processes. The use of various gas mixtures to control oxygen pressures is also described.

CERE 4005. Glass Technology II
2-3-3. Prerequisite: CERE 3008.
Compositions of low, moderate, and high temperature coatings are studied to learn basis of glass properties, adherence, color, opacification, and texture.
Text: at the level of C. W. Parmelee, Ceramic Glasses.

CERE 4018. Drying and Psychrometry
2-0-2. Prerequisite: PHYS 2122.
Fundamental consideration of water removal from unfired ceramic products by heat and air.
Text: at the level of Moody, Drying.

CERE 4042-3. Seminar
1-1-1. Prerequisite: junior standing.
Discussion of current ceramic and scientific literature and reports of investigations.

CERE 4051. Cements
2-3-3. Prerequisite: CERE 3105.
Includes the required properties of raw materials, processing, and the hydraulic properties of cements. Portland, magnesia, high alumina, dentl, and gypsum cements are included.

CERE 4052. Inorganic Phase Analysis and Identification
3-3-4. Prerequisite: PHYS 2122.
Provides the student with the tools to identify a ceramic material using both atomic structure-related techniques and elemental identification. Use of optical crystallography, X-ray diffraction, transmitted and reflected light microscopy and electron microscopy are emphasized as tools to identify ceramic material phases and elemental composition.

CERE 4053. Technical Ceramics
2-3-3. Prerequisites: CERE 3105, PHYS 2122.
Fabrication requirements, property control and structure—property—processing relationships, ceramic dielectrics, ferries, ferroelectrics, piezoelectrics emphasized.

CERE 4054. Process and Temperature Control Instrumentation
3-3-4. Prerequisites: CERE 3101, CERE 3004, or consent of School.
The mathematical and physical basis for the PID control algorithm is covered. Analog and digital temperature instrumentation is explained.

CERE 4102. Refractories
3-3-4. Prerequisites: CERE 3006 and CHEM 3412.
Fundamentals of refractory materials selection and application are stressed. The raw materials for manufacturing refractories and heat transfer through refractory walls are covered.

CERE 4110. Energy Conversion and Control
2-3-3. Prerequisites: CERE 3007 and CERE 4102.
Principles involved in converting various energy resources to thermal energy for use in kilns and furnaces are studied. Materials and devices used in such energy conversion are reviewed. Principles and methods of energy control are detailed.

CERE 4115. Independent Research Project I
1-0-0. Prerequisite: senior standing in Ceramic Engineering.
Each senior conducts an original investigation on an approved ceramic subject under the supervision of the instructor in charge. The object of this course is to place the student on his own initiative and to coordinate the knowledge that he has previously received.

CERE 4116. Independent Research Project II
0-3-1. Prerequisite: CERE 4115.
The senior student formulates an experimental plan under supervision of his advisor, assembles equipment and materials, and begins actual laboratory experimentation.

CERE 4177. Independent Research Project III
0-0-2. Prerequisite: CERE 4116.
Completion of all laboratory work on investigation, submission of preliminary write-up one month before end of quarter, and final submission of approved write-up in acceptable format one week before examination week.

CERE 4801-2.3-4-5. Special Topics
1 through 5 credit hours, respectively.
Prerequisite: consent of School.
New developments in ceramic materials, specialized independent study on topics of current interest.

CERE 6002. Refractories, Selection and Application
3-3-3.
Fundamentals of refractory materials selection and application are stressed. The raw materials for manufacturing refractories and heat transfer through refractory walls are covered.

CERE 6003. Physical Ceramics
2-3-3.
Structural imperfections, diffusion, sintering, and reaction kinetics of ceramic systems are considered. The resultant physical, mechanical, electric, and magnetic properties are related to atomic and macroscopic structures.

CERE 6004. Thermodynamics Applied to Ceramics
2-0-2.
The laws of thermodynamics are applied to ceramic processes and materials. The influence of oxygen pressure on nonstoichiometric compounds is emphasized.

CERE 6011. Colloidal Properties of Hydrous Alumino Silicates
3-3-3. Prerequisite: consent of School.
The physicochemical properties of the plastic and nonplastic hydrous alumino silicate are studied including viscosity, dispersion, flocculation, and permeability.
Text: at the level of Van Olphen, An Introduction to Clay Colloid Chemistry.

CERE 6012. Colloidal Properties of Hydrous Alumino Silicates
3-3-3. Prerequisite: consent of School.
Plastic properties of clay-water systems and industrial applications. Interactions of clay and organic compounds.
Text: at the level of Lawrence, Clay-Water Systems.

CERE 6013. Colloidal Properties of Hydrous Alumino Silicates
3-0-3. Prerequisite: consent of School.
Basic surface properties are studied for application to gas absorption surface area measurements and mineral flotation processes.

CERE 6014-5. Ceramic Applications to the Phase Rule
3-0-3.
Prerequisite: CERE 3105 or consent of School. Phase equilibria in one-, two-, and three-component systems reviewed. Melting and solidification behavior in complex three-component systems examined. Effect of oxygen pressure on phase relations in multicomponent systems surveyed. Applications of thermodynamics to phase diagrams.

CERE 6017-8. Glass Technology
3-0-3 each.
Composition of glass is studied using dynamic considerations. The reasons for the failure of oxide melts to crystallize on cooling are emphasized. Mutual polarization of ions is utilized in analyzing the various glass structures. The different experimental techniques available to study glasses are reviewed.
Text: at the level of Droemars, Glass Science.

CERE 6030. Crystal Structure of Materials I
3-0-3. Prerequisite: consent of School.
Basic crystal structures and relation of different chemical compounds with similar crystal structures. Structures of various clays and complex oxides.
Text: at the level of Evans, Crystal Chemistry, and Wells, Structural Inorganic Chemistry.

CERE 6031. Crystal Structure of Materials II
3-0-3. Prerequisite: consent of School.
Relationship of crystal structure to chemical, physical, and optical properties of high temperature inorganic materials.

CERE 6035. Research and Control Methods
2-3-3. Prerequisite: consent of School.
Emphasis on the experimental and instrumental techniques for research and control measurements. Review of optical, physical, electrical, mechanical measurement techniques, instrumentation, laboratory demonstration.
Text: at the level of Wilson, Introduction to Scientific Research, and Ackoff, Scientific Method.

CERE 6041. Crystal Studies
2-6-4. Prerequisite: CERE 4003 or consent of School.
Fundamentals, methods, and instruments in applications at X-ray diffraction especially the powder method to problems in ceramics and metallurgy.
Text: at the level of Azaroff, Elements of X-ray Crystallography.

CERE 6052. Quantitative Optical and X-ray Crystallography
3-3-4.
Interaction of light and x-rays with periodic crystal lattices is developed in relation to structural identification and quantitative analysis in polycrystalline and mono-crystalline ceramics.

CERE 6053. Electronic and Technical Ceramics
3-3-4.
Processing, properties, and structure of dielectrics, piezoelectrics, ferroelectrics, ferrites, garnets, and other technical ceramics.

CERE 6054. Digital Temperature Instrumentation and Control Systems
2-3-3.
Process control theory is reviewed. Analog and digital instrumentation are compared. Digital control algorithms for simple loops, cascaded loops, and distributed control are discussed.

CERE 6065. Refractory Failure Analysis
2-3-3.
Methods of determining the reason for premature failure of refractories in service are presented. Detailed discussion will be conducted and evaluated in the laboratory.

CERE 6056. Practical Electron Microscopy
2-3-3.
The various types of electron microscopes and how they function will be discussed. The usage of SEM techniques to investigate solid materials will be emphasized.

CERE 6110. Kiln and Furnace Design
2-3-3.
Principles, methods, and devices used to provide heat for operating kilns and furnaces are reviewed. Principles of automatic control are covered. Student designs a kiln equipped with an automatic control system.

CERE 7000. Master's Thesis
3-0-3. Prerequisite: consent of School.

CERE 8102-3-4-5-6-7-8-9. Special Topics
Credit to be arranged.
Specific, well-defined study and measurement problems will be considered and approved for credit upon completion.

CERE 8501-2-3. Special Problems
Credit to be arranged.

CERE 9000. Doctoral Thesis

METALLURGICAL ENGINEERING

MET 3301. Principles and Applications of Engineering Materials
4-3-5. Prerequisites: CHEM 1102 or 1112, 2113, PHYS 2123.
The principles of engineering materials directed toward their application in engineering design. Equilibrium and nonequilibrium structures and properties. Corrosion. Engineering application and failure analysis.
Text: at the level of Van Vlack, Materials for Engineering.

MET 3325. General Metallurgy
3-3-3.
Prerequisites: CHEM 1102, PHYS 2121.
Introductory physical metallurgy and characteristics and engineering applications of cast irons and steels.
Static and dynamic properties of metals and alloys. Not open to students in the School of Chemical Engineering.
Text: at the level of Keyser, Materials Science of Engineering.

MET 4110. Mineral Engineering: Introduction to Formation and Accumulation of Mineral Resources
3-0-3.
The processes of formation and accumulation of ores. Industrial minerals and rocks and fuels, and an introduction to mining and beneficiation.

MET 4112. Mineral Engineering: Introduction to Minerial Economics
3-0-3.
Factors pertaining to the economics of the mineral industries and theoretical and pragmatic concerns in the utilization of mineral resources.

MET 4114. Mineral Engineering: Introduction to Mining
3-0-3. Prerequisite: consent of School.
Evaluation of mining sites; surface and underground mining methods and related equipment. Coal, ores, and industrial minerals and rocks. Safety and environmental aspects of mining.

MET 4115. Mineral Engineering: Economics of the Mineral Industries
3-0-3. Prerequisite: consent of School.
Mineral property titles and concessions, valuation, acquisition and operating costs, marketing, taxation, environmental considerations, and the role of minerals in industrialized nations.

MET 4116. Mineral Engineering: Separation Technology
3-3-3. Prerequisite: junior standing.
A study of the processes for separating mine products and other materials and solid fuels: crushing, grinding, volumetric sizing, classifying and concentration.

MET 4403. Introductory Nuclear Metallurgy
3-3-4. Prerequisites: CHEM 1102, PHYS 2123.
Fundamentals of physical metallurgy, metal crystallites, phase diagrams, properties, fabrication, and testing with emphasis on metals used in nuclear reactor systems. Primarily for NE students. Not open to CHE students.

MET 4411. Basic Extractive Metallurgy
3-3-3. Prerequisite: CHEM 3413 or equivalent.
Theory and practice of extraction and refining of ferrous and nonferrous metals. Calculations and reactions related to pyrometallurgical and hydrometallurgical extractive processes will be emphasized.
Text: at the level of Gilchrist, Extraction Metallurgy.

MET 4421. Nonferrous Metallurgy
3-3-3. Prerequisite: MET 3301 or equivalent.
The influence of processing variables on the structure and properties of nonferrous alloys. Pyrometallurgical instrumentation applied to heat treating and thermal analysis.

MET 4422. Ferrous Metallurgy
3-3-4. Prerequisites: MET 3301, 4421, or equivalent.
The influence of processing variables on the microstructures and properties of steels and ferrous alloys. Heat treating and thermal analysis of ferrous materials.

MET 4423. Metallurgical Fabrication
3-0-3. Prerequisite: MET 3301 or equivalent.
Primary forming techniques and secondary fabrication and joining processes. Some of the processes to be discussed are casting, rolling, forging, extrusion, drawing, machining, and welding.

**MET 4441. Theoretical Physical Metallurgy** 3-0-3. Prerequisite: MET 3301 and CHEM 3413 or equivalent.
A study of the physical and mechanical properties of metals and alloys in the light of their structure. Text: at the level of Cottrell, *An Introduction to Metallography*.

**MET 4445. Electron Microscopy** 2-3-3. Prerequisites: MATH 2308 and MET 3301.

**MET 4446. X-ray Metallurgy** 3-3-3. Prerequisite: MET 3301.

**MET 4463. Metallurgical Testing** 2-3-3. Prerequisite: MET 3301.

**MET 4464. Nondestructive Testing** 2-3-3.

**MET 4491. Corrosion and Protective Measures** 3-0-3. Prerequisites: CHEM 3413 and MET 3325 or 3301.
The electrochemical theory of corrosion, recommended materials, and protective measures for chemical processing equipment and for atmospheric, under-ground, underwater, and elevated temperature exposures. Text: Scully, *The Fundamentals of Corrosion*.

**MET 6005. Dental-Medical Materials** 2-0-2. Prerequisites: MET 3301 and MET 4491.
Theoretical requirements and compatibility of metals as medical implants and a review of up-to-date research. Special lectures will be given by visiting researchers.

**MET 6011. Pyrometallurgy** 3-0-3. Prerequisite: MET 4411 or equivalent.
Pyrometallurgical processes for the production or recycling of ferrous and nonferrous metals.

**MET 6012. Hydrometallurgy** 3-0-3. Prerequisite: MET 4411 or equivalent.
Hydrometallurgical processes used in the production of copper, aluminum, zinc, uranium, and other metals.

**MET 6014. Electrosmelting** 2-3-3. Prerequisite: CHEM 3413 or equivalent.
Electrolytic dissolution and deposition of metals, electrolytic purification, electropolishing, anodizing, and electropolishing.

**MET 6021. Metallurgical Design Problems** 1-6-3. Prerequisite: full graduate standing.
Selection of process equipment, design of special equipment, plant layout and preparation of equipment, utilities, and production costs. Design methods are discussed, evaluated, and utilized.

**MET 6025. Powder Metallurgy** 1-3-2. Prerequisite: MET 4423.

**MET 6033. High Temperature Metallurgy** 2-6-2. Prerequisites: MET 3301, 4491.

**MET 6035. Advanced Nuclear Materials** 3-0-3. Prerequisite: MET 4403 or equivalent.

**MET 6091. Advanced Theory of Metallic Corrosion** 3-3-4. Prerequisite: MET 4491.
The subject matter covers the latest theories and concepts of metallic corrosion.

**MET 6421. Quantitative Characterization of Microstructures** 3-0-3. Prerequisite: graduate standing or consent of instructor.
General, statistically exact methods for describing geometrical attributes of microstructures from random sections. Applications to actual materials or biological specimen. Manual and automatic image analysis techniques.

**MET 6787. Heterogeneous Catalysis** 3-0-3.
Physical chemistry of surfaces; thermodynamics, kinetics, and mechanisms of chemisorption and surface reactions of industrial catalysts. Also taught as CHE 6787.
Text: at the level of Satterfield, *Heterogeneous Catalysis in Practice*.

**MET 7000. Master's Thesis**
Credit to be arranged.

**MET 7041. Advanced Physical Metallurgy I** 3-0-3. Prerequisites: CHEM 3411 or equivalent, MET 4441.

This course will emphasize the dynamical theory of image contrast in thin crystalline foils and its application to the interpretation of lattice defects.

**MET 7046. Advanced Electron Microscopy II** 3-0-3. Prerequisite: MET 4445, 7045.
This course will emphasize the application of theories of electron diffraction and image contrast in thin foils to the types of problems commonly encountered in metalurgy.

**MET 7051. Advanced Mechanical Metallurgy** 3-0-3. Prerequisite: MET 4463.

**MET 7052. Advanced Dislocations and Strengthening Mechanisms I** 3-0-3. Prerequisite: MET 7051.
The emphasis in this course will be on dislocation networks and their effect on the mechanical behavior of materials including both monotonic cyclic properties.

**MET 7053. Advanced Dislocations and Strengthening Mechanisms II** 3-0-3. Prerequisite: MET 7052.
The emphasis in this course will be the interaction of dislocations with other defects and the correlation of these interactions with the mechanical properties of materials including environment's effect on fractures.

**MET 7062. Magnetism in Metals** 3-0-3. Prerequisites: PHYS 6231, MET 4441, 7081.

**MET 7068. Neutron Diffraction** 3-0-3. Prerequisites: PHYS 6231, MET 4441, 4446.

**MET 7081. Metallurgical Thermodynamics** 3-0-3. Prerequisite: MET 4441, CHEM 3412.

**MET 7085. Metallurgical Kinetics** 3-0-3. Prerequisite: MET 7081.
Radiation damage.

**MET 8001. 2-3. Seminar** 2-0-1 each. Prerequisite: graduate standing.
The latest advances in metallurgical research and development will be presented by the enrolled students from articles in recent issues of recognized periodicals.

**MET 8100. Special Topics in Advanced Physical Metallurgy** 3-0-3. Prerequisite: consent of School. Representative subjects include alloy theory, phase transformations, magnetic and electric phenomena in metals, and special topics in diffraction analysis.

**MET 8500. Special Problems (Master's)**
Credit to be arranged.
Lectures, laboratory, and library work on special topics of current interest in metallurgy suitable for a master's candidate.

**MET 9000. Doctoral Thesis**
Credit to be arranged.
Mechanical Engineering Program

General Information

Mechanical engineering traditionally deals with the largest diversity of engineering problems. Because of this general nature, mechanical engineering allows a number of multidisciplinary activities to be conveniently organized within it.

Mechanical engineering embraces the generation, conversion, transmission, and utilization of thermal and mechanical energy, the design and production of tools and machines and their products, the consideration of fundamental characteristics of materials as applied to design, and the synthesis and analysis of mechanical, thermal, and fluid systems, including the automation of such systems. Design, production, operation, administration, economics, and research are functional aspects of mechanical engineering.

The undergraduate curriculum covers the fundamental aspects of the field, emphasizes basic principles, and educates the student in the use of these principles to reach optimal design solutions for engineering problems. Specific design subject matter and materials are also drawn from such engineering activities as solar energy and biomechanical systems as well as from the more traditional areas.

Emphasis in the freshman and sophomore years is on mathematics, chemistry, and physics. Students must pass all required mathematics courses with a grade of "C" or better. The junior and senior years are devoted to the strength of materials and metalurgy, applied mechanics, heat transfer, fluid mechanics, systems and controls, design, and the application of fundamentals to the diverse problems of mechanical engineering. The curriculum stresses laboratory work and design projects. Satisfactory completion of the curriculum leads to the degree Bachelor of Mechanical Engineering.

Optional Programs

Although the structure of the curriculum meets the general educational goals of the majority of mechanical engineering students, the School regularly considers and approves modifications of the basic program to allow a student with certain well-conceived educational objectives to pursue minor fields within the School or within Georgia Tech while earning a degree in mechanical engineering. In this way, a student may achieve his or her basic degree in mechanical engineering while specializing in any one of a large number of other fields. The student who follows the regular ME curriculum takes a number of electives as well as special problems and projects, all of which allow latitude in pursuing his or her educational goals and special interests.

Graduate Programs

The School of Mechanical Engineering has a rapidly expanding and vigorous graduate program of advanced study and research in the areas of acoustics and noise control, applied mechanics, automatic controls, combustion, computer integrated manufacturing, control of machine tools, dynamics and vibration, energy engineering, engineering design, environmental quality control, flammability, fluid mechanics, fluids and fluid power, heat transfer, lubrication, magnetogasdynamics and plasma, computer-aided design, computer-aided manufacturing, manufacturing engineering, materials processing, materials science, mechanisms (synthesis and analysis), plasma engineering, rheology, robotics, solar power, vehicle propulsion, thermal systems, thermodynamics, transport processes, turbomachinery, and two-phase flows.

These graduate programs lead to the degrees Master of Science in Mechanical Engineering, Master of Science, and Doctor of Philosophy for qualified graduates having backgrounds in engineering, mechanics, mathematics, the physical sciences, and the biological sciences.

The master's degree requires a minimum of forty-five approved credit hours. Students may elect to earn fifteen of these hours by writing a thesis, or they may earn all credit toward the degree through course work.

Multidisciplinary Programs

Mechanical Engineering is particularly active in the Computer Integrated Manufacturing Systems (CIMS) Program for study at the graduate level of the integration of design, information and material processing, and management in manufacturing systems. Financial support is available to highly qualified students in the form of the IBM assistantships in CIMS. Industry interaction and unique laboratory opportunities are available in the program. For a complete description and for other multidisciplinary programs, see page 78.

School Facilities

The School of Mechanical Engineering has many types of specialized instruments and equipment associated with laboratories for the study of lubrication and rheology, material processing, fire hazard and combustion, magnetogasdynamics, energetics, fluids and fluid power control, heat transfer, vibration and thermal stress, computer-aided design, automatic control, machinery, microprocessor applications, manufacturing automation, noise, plasmas, robotics, and other areas. The School is housed in a four-building classroom-research complex. Part of this complex is a modern classroom-seminar conference building that serves the entire Institute.

The buildings of the School house many remote terminals linked to the main campus research and teaching computer, as also provided are extensive microcomputer facilities. The machine and instrumentation shops, supported by a full-time staff of technicians, enhance the School's research activities.
Students may obtain additional information about the programs by requesting the Guide to Student Life or Graduate Student Information Brochure or by calling the School at (404) 894-3203. Every student enrolled must consult these resources of information with respect to special rules and degree requirements.

**Bachelor of Mechanical Engineering Curriculum**

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<th>Freshman Year</th>
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<td>ME 3345</td>
<td>Conduction and Radiation Heat Transfer</td>
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<td>ME 3347</td>
<td>Fluid Flow and Convection</td>
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<td>ME 3113</td>
<td>Kinetics and Dynamics of Linkages</td>
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<td>Dynamics of Machinery</td>
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**Sophomore Year**

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<td>ME 2016</td>
<td>Computer Applications</td>
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**Senior Year**

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<td>Design Theory</td>
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<td>ME 4182 or 4317</td>
<td>Mechanical Design Engineering</td>
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<td>ME 4355</td>
<td>Experimental Engineering</td>
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<td>ME 4445</td>
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**Electives⁶** | Humanities/Social Science/Modern Language | 3-0-3 |
| Electives⁶ | Free | 3-0-3 |
| Electives⁶ | ME Design | 3-0-3 |
| Totals | 18-0-18 | 13-6-15 | 16-3-17 |

**Mechanical Engineering**

**Nuclear Engineering and Health Physics Programs**

**General Information**

Nuclear engineering is the branch of engineering directly concerned with the release, control, utilization, and environmental impact of all types of energy from nuclear sources. Today, the diversity of nuclear energy allows a wide variety of applications, from the exploration of outer space and the powering of human heart pacemakers to the generation of electricity. With the limited supply of fossil fuels and the growing concern about their environmental effect, the need for nuclear power to produce the large amount of energy demanded by our society becomes more and more pressing. Programs in Nuclear Engineering and Health Physics are playing a vital role in educating the technical manpower required to meet this need.

In addition to the Bachelor of Nuclear Engineering degree, the School administers the program leading to the Bachelor of Science degree in Health Physics. Health physics is an applied science concerned with the protection of man and the environment from the hazards of radiation and chemical pollutants. Typical activities of health physicists today are development of a sound philosophy and principles of radiation protection; practical application of these principles on the job in an industrial or medical setting or with a regulatory agency; and devising new methods and instrumentation for the protection of individual workers and the general public.
Undergraduate Programs
The curriculum leading to the degree Bachelor of Nuclear Engineering is structured to meet the needs of both the student who contemplates employment immediately after graduation and the student planning to pursue graduate study. It provides maximum flexibility in the form of options for each student to develop his or her unique interests or capabilities. The core curriculum covers the basic principles of nuclear engineering: nuclear reactor core design, nuclear fuel design, reactor systems engineering, nuclear fuel processing engineering, nuclear power economics, and reactor operations.

Study for the bachelor's degree in Health Physics may lead to a career in radiation protection, environmental surveillance, or medical physics or may prepare the student for further study at the graduate level and eventually for a professional career as a health physicist. The program also provides an excellent premedical education.

In addition to the Institute's academic requirements for graduation with a bachelor's degree, the average aggregate grade point ratio in nuclear engineering and health physics courses taken toward the B.N.E. degree or B.S.H.P. degree shall be 2.0 or higher. Further, for students in the B.N.E. program, the average aggregate grade point ratio for courses taken in engineering thermodynamics and transport phenomena shall be 2.0 or higher. Only the highest grade received in any repeated course will be used in calculating quality points for these supplemental criteria.

Graduate Program
Graduate programs in Nuclear Engineering and Health Physics lead to the degrees Master of Science in Nuclear Engineering, Master of Science in Health Physics, and Doctor of Philosophy.

The program at the master's level provides ten areas of emphasis: reactor engineering, reactor operations, nuclear fuels engineering, computer applications, plasma physics, environmental engineering, health physics, medical physics, and industrial health protection.

These curricula are constructed from various combinations of nuclear engineering courses, supplemented with courses in other schools as appropriate. For the first eight areas, students with a Bachelor of Science degree in engineering take the Master of Science in Nuclear Engineering degree while students with a Bachelor of Science degree in science will enroll for the Master of Science degree. While students completing studies in radiation technology or environmental engineering receive the Master of Science degree, students studying health physics receive the Master of Science in Health Physics degree.

Depending on the career objectives of the student, the School may encourage a thesis as part of the Master of Science program. When appropriate, students may substitute approved courses and research experience on a special problem for a thesis.

The doctoral program is designed with great latitude to capitalize on variations in experience and interests of individual students. The School encourages its students to enroll in not only nuclear engineering courses but also courses related to their subject areas and offered by other schools.

Multidisciplinary Programs
See table on page 78.

Facilities
The facilities available on the Georgia Tech campus for instruction and research in nuclear engineering include the following: a 5-megawatt research reactor, a sub-critical assembly, 100,000 curie cobalt-60 sources, several small digital computers, a CDC CYBER 170/855 and 170/835 computer, IBM 4341 and VAX 11/750, hot cells for handling radioactive materials, a complete nuclear instrumentation laboratory, nuclear radiography equipment, radiocexval laboratories, and facilities for analyzing environmental samples by nuclear techniques.
Bachelor of Science in Health Physics Curriculum

<table>
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<td>MATH 2309</td>
<td>Ordinary Differential Equations</td>
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Courses of Instruction


ME 2212. Materials Science 3-0-3. Prerequisites or corequisites: MATH 3308, PHYS 2123. Mechanical behavior, elastic and plastic properties, annealing of cold-worked materials leading from atomic concepts, crystallography, and relation of crystal defects to properties.

Technical electives will be selected by the student after consultation with his or her adviser. A list of acceptable biology electives is available in the office of the Nuclear Engineering and Health Physics Programs.
ME 3086. Experimental Methodology 2-3-3. Prerequisites: MATH 3308 and ME 3322.

Presentation of experimental methodology and basic instrumentation used in mechanical engineering and its calibration and use, accuracy, error, and uncertainty in experimental measurements.

ME 3110. Creative Decisions and Design 2-3-3. Prerequisite: junior or senior standing.

Basic concepts for creative decisions in engineering problem solving and design. Exposure to practicing engineers, their industries, and design problems.

ME 3113. Kinematics and Dynamics of Linkages 3-0-3. Prerequisite: ESM 3201.

Kinematics and dynamics of linkages with emphasis on inertial forces. Balancing of rotating and reciprocating systems.

ME 3114. Dynamics of Machinery 3-0-3. Prerequisites: ME 3113, MATH 3308.

Dynamics modeling of systems with mechanical, fluid, thermal, and/or electrical elements. Analysis including linearization, transient and frequency response, and stability. Vibration of mechanical systems.

ME 3181. Design of Machine Elements 3-0-3. Prerequisites: ESM 3301, ME 3121.

Methodology and applications in designing machine components by means of integrating the general principles and empiricism of solid mechanics, materials, metal fatigue, and other disciplines.

ME 3183. Rational Descriptions and Engineering Design 3-0-3. Prerequisite: junior standing in engineering.

Information-theory decision analysis for engineering design with practical applications to the design of mechanical, thermal, and electrical components and systems.

ME 3212. Materials Technology 3-3-4. Prerequisite: ME 2121.

Mechanical and physical properties of metallic and nonmetallic materials, structure/property relationships, and variables related to behavior under service conditions. Phase equilibria, microstructure, steels, heat treatment, annealing, fracture, fatigue, creep.

ME 3322. Thermodynamics I 3-0-3. Prerequisite: or corequisites: PHYS 2123.

An introduction to thermodynamics. Thermodynamic properties, state postulate, work interactions, steady state and transient energy and mass conservation, entropy and the second law.

ME 3323. Thermodynamics II 3-0-3. Prerequisite: ME 3322.

Continuation of ME 3323. Gas and vapor power cycles, vapor and gas absorption refrigeration cycles. First and second laws of thermodynamics, Gibbs phase rule, chemical equilibrium.

ME 3340. Fluid Mechanics I 3-0-3. Prerequisite: ESM 3201, ESM 3301, MATH 3308. Prerequisite or corequisite: ME 3322.

Introduction to fluid mechanics, fluid statics, integral and differential control volume analyses with applications to study of similitude, simple laminar flows.

ME 3345. Conduction and Radiation Heat Transfer 3-0-3. Prerequisite: MATH 3308. Prerequisite or corequisite: ME 3322.

Introduction to the study of heat transfer, transport coefficients, steady state conduction, transient conduction, radiative heat transfer.

ME 3347. Fluid Flow and Convection 3-0-3. Prerequisites: ME 3340, ME 3345.

Transition and turbulence in fluid flow, laminar and turbulent boundary layers, forced and natural convection, one-dimensional compressible flow.

ME 3720. Thermodynamics 4-0-4. Prerequisites: or corequisites: PHYS 2123, MATH 2306.

Not for ME students.

Mechanical and physical properties of metallic and nonmetallic materials, structure/property relationships, and variables related to behavior under service conditions. Phase equilibria, microstructure, steels, heat treatment, annealing, fracture, fatigue, creep.

ME 3322. Thermodynamics I 3-0-3. Prerequisite: or corequisites: PHYS 2123, MATH 2306.

An introduction to thermodynamics. Thermodynamic properties, state postulate, work interactions, steady state and transient energy and mass conservation, entropy and the second law.

ME 3323. Thermodynamics II 3-0-3. Prerequisite: ME 3322.

Continuation of ME 3323. Gas and vapor power cycles, vapor and gas absorption refrigeration cycles. First and second laws of thermodynamics, Gibbs phase rule, chemical equilibrium.

ME 3340. Fluid Mechanics I 3-0-3. Prerequisite: ESM 3201, ESM 3301, MATH 3308. Prerequisite or corequisite: ME 3322.

Introduction to fluid mechanics, fluid statics, integral and differential control volume analyses with applications to study of similitude, simple laminar flows.

ME 3345. Conduction and Radiation Heat Transfer 3-0-3. Prerequisite: MATH 3308. Prerequisite or corequisite: ME 3322.

Introduction to the study of heat transfer, transport coefficients, steady state conduction, transient conduction, radiative heat transfer.

ME 3347. Fluid Flow and Convection 3-0-3. Prerequisites: ME 3340, ME 3345.

Transition and turbulence in fluid flow, laminar and turbulent boundary layers, forced and natural convection, one-dimensional compressible flow.

ME 3720. Thermodynamics 4-0-4. Prerequisites or corequisites: PHYS 2123, MATH 2306.

Not for ME students.

ME 3720. Thermodynamics 4-0-4. Prerequisites or corequisites: PHYS 2123, MATH 2306.

Not for ME students.

ME 3720. Thermodynamics 4-0-4. Prerequisites or corequisites: PHYS 2123, MATH 2306.

Not for ME students.

ME 3720. Thermodynamics 4-0-4. Prerequisites or corequisites: PHYS 2123, MATH 2306.

Not for ME students.

ME 3720. Thermodynamics 4-0-4. Prerequisites or corequisites: PHYS 2123, MATH 2306.

Not for ME students.

ME 3720. Thermodynamics 4-0-4. Prerequisites or corequisites: PHYS 2123, MATH 2306.

Not for ME students.
Solar energy resources, collector models, active DHW and space heating systems, passive heating. Utilization and design-chart methods. Introduction to cooling, photovoltaic, wind, and OTEC systems. Design projects.

ME 4455. Automatic Control
3-0-3. Prerequisite: ME 3016, ME 3114.
Analysis and modeling of linear systems and compensation of feedback controlled systems using classical methods. Hydraulic, pneumatic, thermal, electrical, nuclear, chemical, and biomechanical examples.

ME 4469. Numerical Control of Machine Tools
3-0-3. Prerequisite or corequisite: ME 4445.
Study of design and operation of typical digital control systems for machine tools, including the flow of signals through the system.

ME 4714. Heat Transfer
3-0-3. Prerequisite: ME 3720, 2016 or equivalent. Not for ME students.
Transport processes, concepts of conduction, convection, and radiation. Boundary layer analysis in convective laminar and turbulent flows. Stationary systems, including external/internal resistance criteria.

ME 4760. Engineering Acoustics and Noise Control I
3-0-3. Prerequisite: senior standing.
Study of acoustics related to noise and its control, acoustic terminology, wave propagation, solutions to the wave equation, instrumentation, sound fields in large and small rooms, noise legislation.

ME 4761. Engineering Acoustics and Noise Control II
3-0-3. Prerequisite: ME 4761 or equivalent.
Continuation of ME 4760 emphasizing techniques for the solution of noise problems. Vibration isolation, energy absorption, dissipative and reactive mufflers, enclosures, barriers, properties of materials, panel damping.

ME 4771. Pulb and Paper Processes I
3-0-3. Prerequisite: consent of School.
A survey of the processes in a Kraft pulp mill necessary to convert raw material to sulfate pulp. Wood preparation, wood chemistry and morphology. The chemical and mechanical characteristics of Kraft pulping and chemical recovery processes. Cross-listed with CHE.

ME 4772. Pulp and Paper Processes II
3-0-3. Prerequisite: consent of School.
The major pulping processes other than Kraft pulping. General knowledge of the various factors affecting each pulping process and pulp bleaching. The unique advantages and disadvantages of each pulping and bleaching process. Cross-listed with CHE.

ME 4773. Paper Formation and Properties
3-0-3. Prerequisite: consent of School.
The processes in the fabrication of paper and paper products from pulp. The effects on paper properties of chemical and mechanical pretreatment of pulp. The measurement of paper properties. Cross-listed with CHE.

ME 4780. Energy Conversion Engineering
3-0-3. Prerequisite: ME 3720 or equivalent.
Energy sources, basic principles of semiconductors, thermoelectric converters, solar power, thermionic systems, MHD, applications of these devices for power generation, environmental effects, cost factors.

ME 4801-3-4-5. Special Topics, Mechanical Engineering
1-0-1 to 5-0-5, respectively.
Special topic offerings of current interest not included in regular courses.

ME 4901 through 4912. Special Problems, Mechanical Engineering
Credit to be arranged.
Individual studies in certain specialized areas, and mathematical analyses and/or experimental investigations of problems of current interest in mechanical engineering.

ME 6141. Engineering Instrumentation
3-3-4. Prerequisite: ME 3056 or equivalent or graduate standing.
Methods and techniques of modern instrumentation in engineering research. Emphasis on analytical methods in planning and evaluation of experiments, integration of experimentation theory with practical aspects of instrumentation problems.

ME 6024-5. Variational Methods in Engineering I,II
3-0-3 each. Prerequisite: ME 3347, ESM 3302, or equivalent.
Variational methods applied to the optimization of engineering systems, the formulation and approximate solution of differential equations with application to nonlinear vibration, fluid mechanics, heat transfer, hydrodynamic stability, and automatic control.

ME 6121. Advanced Dynamics of Machinery
3-0-3. Prerequisite: consent of School.
Design-oriented dynamics. Dynamics of systems with periodic and random sources.

ME 6122. Machine Vibration
3-0-3. Prerequisite: consent of School.
Frictional phenomena, slip line fields, upper bound forces, material properties, and characteristics.

**ME 6322. Thermodynamics I**
3-0-3. Prerequisite: undergraduate thermodynamics. Thorough study of the principles of macroscopic formalism of thermodynamics. Thermodynamic systems, pure substance, multi-phase mixtures, reactive systems.

**ME 6323. Thermodynamics II**
3-0-3. Prerequisite: undergraduate thermodynamics. Microscopic thermodynamics based on classical mechanics, quantum mechanics, and information theory. Prediction of macroscopic properties and system behavior from statistical considerations.

**ME 6324. Thermodynamics III**
3-0-3. Prerequisite: ME 6323 or equivalent. Statistical thermodynamic calculation of properties of ideal gases, real gases, solids, and gas mixtures. Kinetic theory and transport properties. Thermodynamics of special systems.

**ME 6325. Information Theory Thermodynamics**
3-0-3. Prerequisite: ME 6323 or consent of School. A derivation from information theory of the fundamentals of thermodynamics and statistical mechanics. Applications to irreversible thermodynamics and the design of thermosystems.

**ME 6332. Heat Transfer I**
3-0-3. Prerequisite: ME 3347 or consent of School. Conduction-steady state and transient, one- and multidimensional geometries. Emphasis on analytical methods, exact and approximate, on numerical and graphic techniques.

**ME 6333. Heat Transfer II**
3-0-3. Prerequisite: ME 6332 or consent of School. Convection-forced and free, in laminar and turbulent, internal and external flows. Analogy between momentum and heat transfer. Scaling laws and partial modeling.

**ME 6334. Heat Transfer III**
3-0-3. Prerequisite: graduate standing. Radiation-electrodynamics, radiation optics, photon gas concept, black body radiation, surface characteristic, exchange in enclosures, radiation through conduits, experimental methods.

**ME 6338. Advanced Theory of Heat Transfer**
3-0-3. Prerequisites: ME 6332, 6333. Advanced mathematical methods in conduction and convection, ablation, solidification, packed and fluidized beds, condensation, boiling heat transfer, heat transfer in porous media, transient boundary layers.

**ME 6342. Fluid Flow I**
3-0-3. Prerequisite: ME 3340 or consent of School. A general development of the continuity, linear and angular momentum equations followed by the fundamentals of perfect fluid theory.

**ME 6343. Fluid Flow II**
3-0-3. Prerequisite: ME 6342 or equivalent. Viscous flow theory including derivation of Navier-Stokes equations, a study of their general properties and their applications to creeping flow and to laminar and turbulent boundary layers.

**ME 6344. Fluid Flow III**
3-0-3. Prerequisite: ME 6343 or equivalent. Turbulent flow theory, origins of turbulence, turbulent stress, mixing-length models, free turbulent flow, flow in pipes and boundary layers, statistical description of turbulence.

**ME 6351. Direct Energy Conversion**
3-0-3. Prerequisite: ME 3720 or equivalent. Analysis of performance characteristics, based on thermodynamic and fluid flow principles of direct energy conversion devices such as thermionic, thermoelectrics, photovoltaic, magnetohydrodynamic, electrohydrodynamic generators, and fuel cells.

**ME 6352. Energy Conversion Systems**
3-0-3. Prerequisite: ME 3324 or equivalent. A study of alternative energy conversion systems and analysis of their economic and commercial performance characteristics. Comparative analysis of Otto, Diesel, Brayton, Rankine, solar and direct energy conversion systems.

**ME 6353. Diagnostics of Combustion Gases and Plasmas**

**ME 6355. Combustion I**

**ME 6356. Combustion II**
3-0-3. Prerequisite: ME 6355 or equivalent. Combustion of liquid and solid fuels. Combustion in laminar boundary layers.

**ME 6357. Combustion III**
3-0-3. Prerequisite: ME 6356 or equivalent. Combustion in turbulent boundary layers. Spontaneous ignition and explosions. Flame propagation and flammability limits.

**ME 6360. Solar Energy Engineering**

**ME 6370. Thermal Environmental Control**

**ME 6371. Advanced Refrigeration**
3-0-3. Prerequisite: consent of School. Development of refrigeration and performance characteristics of vapor compression, absorption, and several other work and heat input refrigeration cycles. Specification of desirable refrigerant properties.

**ME 6376. Internal Combustion Engine Design**
3-0-3. Prerequisite: ME 4324 or equivalent. Development of engine design practice to accommodate challenges of application, efficiency, emissions, and balance.

**ME 6377. Internal Combustion Engines**
3-0-3. Prerequisite: ME 6355 or equivalent. Principles of operation of reciprocating and rotating engines including analysis of pollutant formation and methods of its control.

**ME 6379. Turbines**
3-0-3. Prerequisite: ME 4339, 4326, or consent of School. Basic fluid mechanics and thermodynamics of the expansion processes in various types of radial and axial flow turbines. Current literature is discussed.

**ME 6383. Power Generation**
3-0-3. Prerequisite: consent of School. Hydrodynamics, hydrostatic, and solid lubrication, elastohydrodynamic lubrication, lubricant properties, boundary lubrication, friction and solid lubricants are covered from fundamental development through design considerations.

**ME 6424. Feedback Control Systems I**
3-0-3. Prerequisite: graduate standing. Linear systems. Integration of classical (root locus, frequency response) and modern (state feedback, observers) techniques. Mechanical, thermal, fluid, chemical, and nuclear examples.

**ME 6425. Feedback Control Systems II**
3-0-3. Prerequisite: ME 4445, 6424, or equivalent. Time domain and sampled data and digital control. Phase plane, describing functions and Lyapunov methods.

**ME 6426. Feedback Control Systems III**

**ME 6437-8. Digital Control Systems I and II**
3-0-3, 3-3-4. Prerequisite: graduate standing or consent of School. ME 6437 is prerequisite for 6438. The basic theory and techniques employed in the design of control systems for numerically controlled machine tool and digital computers.

**ME 6439. Control System Components**
2-1-3. Prerequisite: ME 4445 or equivalent. The performance characteristics and the mathematical modeling of control system components, including transient and frequency response tests.

**ME 6440. Fluid-Power Control Systems**
3-0-3. Prerequisite: ME 4445 or equivalent. Analysis and synthesis of control systems using liquids and gases. Dynamic characteristics and specifications of control system components, closed-loop fluid-power control systems.

**ME 6471. Control of Engineering Processes**
3-0-3. Prerequisite: ME 6424 or equivalent. Large-scale computer solutions and simulation. Distributed parameter system modeling and analysis. Current interest topics of practical significance not in ME 6424-5-6.

**ME 6750. Systems Design Methodology**
2-3-3. Prerequisite: graduate standing or consent of School. Relationship of technological systems to society is studied using economic concepts. Emphasis on the use of engineering type analysis in resolving value laden problems. Examples. Cross-listed with AE, EE, CE, CP, ISYE.

**ME 6751-2. Complex Systems Design I, II**
2-4-3 each. Prerequisite: graduate standing in any school or senior standing with consent of School. Interdisciplinary team design of systems of current interest to society which have large technological factors. Individual research and interaction with noninstitutional persons and faculty. Grades based on oral and written reports. Cross-listed with AE, EE, CE, CP, ISYE.

**ME 6760-1. Acoustics I and II**

**ME 6762. Acoustics III**
3-0-3. Prerequisite: ME 6761. Advanced duct acoustics, wave dispersion and attenuation, acoustics in moving media, geometrical acoustics, nonlinear acoustics.

**ME 6763. Noise Reduction and Control (Industrial Applications)**
3-0-3. Prerequisite: ME/AF/ESM 6760, 4025 or equivalent. Mathematical model of noise reduction and control applied to systems in industry. Measurement of sound power, material acoustic properties, barriers, enclosures, mufflers, vibration reduction, and damping methods.

**ME 6764. Ocean Acoustics**
3-0-3. Prerequisite: GEOS 4300 or consent of School. MATH 4321, 4582, ESM 6760 recommended. Advanced electrodynamics, wave propagation, and scattering, acoustics in moving media, geometrical acoustics, nonlinear acoustics.

Curricula and Courses of Instruction

Mechanical Engineering
ME 7000. Master's Thesis
ME 7035. Numerical Methods in Mechanical Engineering
3-0-3. Prerequisite: graduate standing.

ME 7122. Advanced Machine Vibrations
3-0-3. Prerequisite: ME 6122 or consent of School.

ME 7140. Decision Theory for Engineering Design
3-0-3. Prerequisite: MATH 4215 or consent of School.
Use of information-theory decision analysis in solving practice problems in engineering design and reliability, which cannot be effectively treated by any other method.

ME 7220. High Temperature Deformation Processes
3-0-3. Prerequisite: ME 4265.
Mechanical properties of materials at elevated temperatures, creep behavior, deformation mechanisms, stress analysis. Design for temperature effects. Thermal stress, notches, fracture, fatigue, corrosion, and oxidation.

ME 7222-3. Fracture and Fatigue of Material I, II
3-0-3 each. Prerequisite: ME 6271.

ME 7322. Thermodynamics of Irreversible Processes I
3-0-3. Prerequisite: ME 7222 or equivalent.
Principles and formalism of thermodynamics of near-equilibrium states. Phenomenological equations and the Onsager-Casimir reciprocal relations. Coupled linear processes and cross-effects.

ME 7323. Thermodynamics of Irreversible Processes II
3-0-3. Prerequisite: ME 7322 or equivalent.

ME 7336. Forced Convection Heat Exchange
3-0-3. Prerequisite: ME 6333.
Theory of forced convection heat exchange in recuperators, regenerators, and devices with simultaneous heat and mass transfer, with emphasis on performance and thermal design.

ME 7338. Advanced Topics in Heat Transfer
3-0-3. Prerequisite: ME 6332, 6333, 6334.
Latest advances in heat transfer, boiling, and two-phase flows, liquid metal heat transfer, influence of main stream turbulence, separated flows, porous media, radiation and conduction.

ME 7341. Transport Phenomena in Two-Phase Flow I
3-0-3. Prerequisite: consent of School.
Dispersed and separated flows—field and constitutive equations, jump conditions. Interfacial phenomena, nucleation, Two-fluid and drift models, similarity criteria. Dynamics, propagation phenomena, kinematic waves.

ME 7342. Transport Phenomena in Two-Phase Flow II
3-0-3. Prerequisite: consent of School.

ME 7399. Preparation for Doctoral Qualifying Exam
Audit only. Prerequisite: consent of School.

ME 8009. Heat Transfer Seminar
1-0-1.
Two presentations by each student of current research activities: thesis work and special problems, presentation of thesis proposals. Attendance in curriculum-related seminars.

ME 8041-2. Fluid Mechanics Seminar
1, 2, 3, 4 hours, respectively. Prerequisite: consent of School.
Advisory, current topics in fluid mechanics and fluid engineering including applications of interest to mechanical engineering.

ME 8101-2. Special Topics in Design
1, 2, 3, 4, 5 credit hours, respectively. Prerequisite: consent of School.
Special topic offerings of current interest not included in regular courses.

ME 8301-2. Special Topics in Materials
1, 2, 3, 4, 5 credit hours, respectively. Prerequisite: consent of School.
Special topic offerings of current interest not included in regular courses.

ME 8501. Special Problems in Mechanical Engineering
Credit to be arranged. Prerequisite: consent of School.
Individual studies in certain specialized areas and mathematical analyses and/or experimental investigations of problems of current interest in mechanical engineering.

ME 8999. Preparation for Doctoral Dissertation
Audit only. Prerequisite: consent of School.

ME 9000. Doctoral Thesis

NUCLEAR ENGINEERING

NE 1010. Computer Programming for Nuclear Engineers
3-0-3.
FORTRAN computer programming, graphics, and elementary numerical methods for NE freshmen will be taught using terminals to interact with the main computer on campus.

NE 1100. Energy and Engineers in Society
2-3-3.
Deals with the concept of energy, society's requirements, the sources of supply, power generation methods, and related environmental influences.

NE 3110. Nuclear Radiation Detection
2-6-4. Prerequisite: PHYS 3001.
A laboratory introduction to the principles and characteristics of basic detectors for nuclear radiations and the electronic systems associated with them.

NE 3211. Elements of Nuclear Engineering
3-0-3. Prerequisite: PHYS 2123. Corequisite: MATH 2501.
An introduction to the field of nuclear engineering. Topics include neutron interactions in matter, the classification of fission chain reactors, nuclear fuels, and neutron diffusion theory.

NE 4011-2. Nuclear Engineering Seminar
1-0-1 each.
A regularly scheduled course required of NE seniors. Various topics presented by guest speakers, faculty members, and graduate students.

NE 4115. Nuclear Engineering Calculations with Digital Computers I
2-0-1.
Introduction to computer programming with emphasis on solution of problems relevant to nuclear engineering.

NE 4201. Nuclear Reactor Physics I
3-0-3. Prerequisites: PHYS 3001, NE 3211. Corequisite: MATH 4582.
The course covers the physical principles of nuclear reactors. Major topics include the diffusion equation, neutron moderation, neutron thermalization, and criticality conditions.

NE 4202. Nuclear Reactor Physics II
3-0-3. Prerequisite: NE 4201.
Topics include the multigroup diffusion method, heterogeneity effects, reactor kinetics, and reactivity changes.

NE 4205. Reactor Laboratory
1-6-3. Prerequisite: NE 4202. Students registering for NE 4205 must receive an access permit to the nuclear reactor from the director of the Nuclear Research Center one quarter prior to taking the course.

NE 4210. Reactor Operations
1-6-3. Prerequisites: senior standing and consent of School. Students registering for NE 4210 must receive an access permit to the nuclear reactor from the director of the Nuclear Research Center one quarter prior to taking the course.
Provides experience in all phases of reactor operation.

NE 4211. Reactor Engineering I
3-0-3. Prerequisite: ME 3720 or equivalent.
Current and proposed nuclear reactor power plants. Thermodynamic and fluid flow aspects of reactor system design. Heat generation and conduction in nuclear reactor systems.

NE 4212. Reactor Engineering II
3-0-3. Prerequisite: NE 4211, ISYE 4725, or equivalent.

NE 4230. Nuclear Engineering Design
2-6-4. Prerequisites: NE 4212, 4202.
A complete design project of a nuclear power plant section or of a nuclear fuel cycle facility.

NE 4260. Radiation Transport and Shielding
3-0-3. Corequisite: NE 4202 or equivalent.
Transport theory as applied to radiation transport in homogeneous and heterogeneous bulk media. Emphasis on neutron and gamma-ray transport, both theoretical and applied.

NE 4261. Boiling Water Reactor Systems and Operations
3-0-3. Prerequisite: NE 4701, 4201, or consent of School.
An analysis of operating characteristics of boiling water reactors.

NE 4265. Light Water Reactor Technology
3-0-3. Prerequisite: senior standing in nuclear engineering.
A systematic survey of the technology of both pressurized and boiling water reactors with emphasis on the nuclear steam supply system and its associated safety and control systems.

NE 4301. Nuclear Fuel Cycle
3-0-3. Prerequisite: senior standing in nuclear engineering or consent of School.
Systematic review of technologies used at fuel cycle facilities (other than reactors). Introduces economic, energy, environmental, safety, and licensing aspects.
Introduction to Fusion Power 3-0-3. Prerequisite: consent of School. Basic plasma physics and technology of magnetic confinement devices. Current reactor designs are discussed.

Isotopic Tracer Methodology 2-3-3. Prerequisite: consent of School. Introduction to isotopic tracer techniques for scientific applications.

NE 4001-2-3-4. Special Topics 3-0-3. Prerequisite: consent of School. Special topics of current interest in science or engineering. Programs are written and run in FORTRAN.

NE 4126. Monte Carlo Methods in Nuclear Engineering 3-0-3. Prerequisite: consent of School. Introduction to Monte Carlo methods with application to radiation transport. Statistical background, generation and testing of pseudorandom numbers, random variables, applications to shielding and reactor physics, variance reduction methods.

NE 4101. Introduction to Nuclear Materials 3-0-3. Introduction to the nuclear fuel cycle, raw materials, extraction, enrichment, fabrication, reprocessing. Metallurgy of uranium, ceramic fuels, cladding and control materials and coolants.

NE 4102. Nuclear Fuel Elements 3-0-3. Prerequisite: NE 6101 or consent of School. Reactor fuel elements, including fuel fabrication, assembly, and testing. In-core performance of fuel elements and fuel design procedures.

NE 4103. Nuclear Reactor Analysis I 3-0-3. Prerequisite: graduate standing or consent of School. Nuclear reactor physics at the graduate level. Major topics include neutron diffusion, diffusion theory, and energy group constants. Text: at the level of Henry, Nuclear Reactor Analysis.


NE 4110. Radiation Detection I 2-6-4. Prerequisite: PHYS 6011 or equivalent. Principles of radiation detection systems in common use. Included are interaction mechanics, detector response, design, and selection criteria for detectors and indicating circuits. A continuation of NE 4101. Topics include: adjoint equations, perturbation theory, variational methods, neutron thermalization, resonance absorption, and reactor dynamics.


NE 6101. Introduction to Nuclear Materials 3-0-3. Introduction to the nuclear fuel cycle, raw materials, extraction, enrichment, fabrication, reprocessing. Metallurgy of uranium, ceramic fuels, cladding and control materials and coolants.

NE 6102. Nuclear Fuel Elements 3-0-3. Prerequisite: NE 6101 or consent of School. Reactor fuel elements, including fuel fabrication, assembly, and testing. In-core performance of fuel elements and fuel design procedures.

NE 6103. Nuclear Reactor Analysis I 3-0-3. Prerequisite: graduate standing or consent of School. Covers nuclear reactor physics at the graduate level. Major topics include neutron imaging, diffusion theory, and energy group constants. Text: at the level of Henry, Nuclear Reactor Analysis.


NE 6110. Radiation Detection I 2-6-4. Prerequisite: PHYS 6011 or equivalent. Principles of radiation detection systems in common use. Included are interaction mechanics, detector response, design, and selection criteria for detectors and indicating circuits. A continuation of NE 4101. Topics include: adjoint equations, perturbation theory, variational methods, neutron thermalization, resonance absorption, and reactor dynamics.

NE 6111. Advanced Radiation Detection 3-0-3. Prerequisite: NE 6110 or equivalent. Selected topics on modern radiation detection methods and fast pulse-circuit systems. Emphasis on neutron detection methods, scintillation detectors, and semiconductor devices.

NE 6113. Radiation Effects on Materials 3-0-3. Prerequisite: NE 6110 or equivalent. Review of major effects of radiation damage and related structural changes in solids. Semiconductors, organic materials, and reactor components are covered.

NE 6125. Nuclear Engineering Calculations with Digital Computers I 3-0-3. Prerequisite: NE 4115 or equivalent. Reviews numerical analysis with application to problems of nuclear reactors and related nuclear physics and engineering. Programs are written and run in FORTRAN.

NE 6126. Monte Carlo Methods in Nuclear Engineering 3-0-3. Prerequisite: consent of School. Introduction to Monte Carlo methods with application to radiation transport. Statistical background, generation and testing of pseudorandom numbers, random variables, applications to shielding and reactor physics, variance reduction methods.


NE 6201. Advanced Nuclear Reactor Physics I 3-0-3. Prerequisite: NE 6104. The course covers the neutron transport equation and its solution by spherical harmonics, Fourier transforms, and discrete ordinates methods. Multigroup methods are also covered.

NE 6202. Advanced Nuclear Reactor Physics II 3-0-3. Prerequisite: NE 6201. A continuation of NE 6201. Topics include: adjoint equations, perturbation theory, variational methods, neutron thermalization, resonance, absorption, and reactor dynamics.

NE 6205. Nuclear Engineering Laboratory 1-6-3. Prerequisite: NE 6104. Students registering for NE 6295 must receive an access permit to the nuclear reactor from the director of the Nuclear Research Center one quarter prior to taking the course. Sequence of experiments elucidating reactor physics principles. Nuclear reactors, subcritical assembly, pulsed neutron generators, and isotopic neutron sources are used.


NE 6220. Advanced Reactor Fuel Cycle I -6-3. Prerequisite: NE 6104. Students registering for NE 6205 must receive an access permit to the nuclear reactor from the director of the Nuclear Research Center one quarter prior to taking the course. Sequence of experiments elucidating reactor physics principles. Nuclear reactors, subcritical assembly, pulsed neutron generators, and isotopic neutron sources are used.


NE 6260. Radiation Attenuation 3-3-4. Prerequisite: NE 6104. Interaction of radiation with matter in bulk, absorption, scattering, and attenuation of nuclear radiation, radiation transport theory, geometrical considerations, and transport solution methods.

NE 6601. Radioisotope Engineering I 3-0-3. Prerequisite: PHYS 6011 or equivalent. Production and handling of radioisotope sources. Industrial and medical applications of tracer methods and radiation sources. Design procedures for radiation gauges and high-level irradiation facilities.

NE 6602. Radioisotope Engineering II 3-0-3. Prerequisite: NE 6601. Production and economics of large-scale radiation sources for process systems and power sources. Analysis and design of practical systems and case studies.

NE 6615. Fusion Fundamentals 3-0-3. Prerequisite: graduate standing in engineering or science. A review of selected topics in mathematics and physics that are required for graduate study in fusion. Atomic processes in ionized gas, nuclear reactions, interaction of radiation with water, reactor analysis, generalized curvilinear coordinates, and Fourier analysis are covered.

NE 6623. Fusion Plasma I 3-0-3. Prerequisite: NE 4610 or equivalent. Fundamental plasma fusion plasma properties, motion of charged particles in magnetic fields, fluid description of -plasmas, and transport processes in magnetically con- fined plasmas.

NE 6624. Fusion Plasma II 3-0-3. Prerequisite: NE 6623. Plasma equilibrium and stability waves in plasmas, plasma heating and fueling, radiative processes, plasma-wall interaction, plasma dynamics, fusion reactor plasma parameters.
NE 6625. Fusion Reactor Technology
3-0-3. Prerequisites: NE 6624 and NE 6632.
Technology and physics aspects of fusion reactor plant analysis and design, superconducting magnets, neutral beams, vacuum systems, confinement concepts, economics analysis and optimization.

NE 6626. Plasma Equilibrium and Transport
3-0-3. Prerequisite: NE 6624.
Advanced treatment of plasma equilibria with flows, fluid and kinetic theories of plasma transport, and the evolution of flux surface configurations.

NE 6627. Plasma Waves and Instabilities
3-0-3. Prerequisite: NE 6624.
Study of the plasma as a dielectric medium. Construction of the dielectric tensor and dispersion relations for magnetized plasmas. Instabilities in homogeneous and inhomogeneous plasmas and an introduction to plasma turbulence.

NE 6631. Fusion Nuclear Engineering I
3-0-3. Prerequisite: NE 4610. NE 6615. NE 6103, or equivalent.
Neutronics and photonics analysis and design of the blanket and shield for fusion reactors, tritium breeding, nuclear heating, response functions, induced activation, radiation transport and protection.

NE 6632. Fusion Nuclear Engineering II
3-0-3. Pre/Corequisite: NE 6631. MET 4403. ME 3212, or equivalent.
Materials and thermal-hydraulics analysis and design of the first wall and blanket for fusion reactors, radiation damage and radiation effects, heat transfer and transport.

NE 6680. Advanced Energy Conversion I
3-0-3.
Topics include energy sources, dynamic systems, thermoelectric conversion, fuel cells, solar power, MHD and the design of practical and useful power systems.

NE 6681. Advanced Energy Conversion II
3-0-3. Prerequisite: NE 6680.
Explores the topics covered in NE 6680 in greater depth. Current programs aimed at developing advanced power sources are discussed.

NE 6760. Financial Management and Economics of Nuclear Power
3-0-3. Prerequisite: consent of School.
Topics include reactor and fuel cycle, electrical power systems and utility economics, financial management and system modeling. Identical to ECON 6760.

NE 6770. Small Computer Interface Engineering and Applications
2-6-4.
The use of computers in data acquisition and control digital logic, interfacing, computer structures, and the hardware-software trade-off are covered. First course in computer engineering options.

NE 6771. Engineering Computer Software Systems
3-3-4. Prerequisite: NE 6770.
Computer programming for real-time process control systems in complex multiple-task device-oriented environments. Subjects include assembler programming, operating systems, and real-time systems on minicomputers.

NE 6772. Advanced Computer Interfacing and Digital Design
2-3-3. Prerequisite: NE 6770.
A study of system design using MSI and LSI chips and programmable digital devices as system modules. Subjects include Boolean optimization and register transfer design techniques.

NE 6773. Computer Control of Real-Time Systems
3-3-4. Prerequisite: NE 6770, EE 4077, or equivalent.
A study of computer control of all computer-controlled real-time systems. Subjects include evolution of time sets, vectored interrupts, and statistical alarm conditions.

NE 6775. Advanced Engineering Programming Methods
3-3-4. Prerequisite: FORTRAN programming knowledge.
Advanced engineering programming concepts and their implementation on large-scale digital computers. Dynamic data, dynamic programs, engineering data management, primary memory management, engineering problem-oriented language development and IES.

NE 7000. Master's Thesis
Credit to be arranged.

NE 7999. Preparation for Doctoral Qualifying Examination
Audit only. Prerequisite: consent of School.
Students who are preparing for their qualifying examinations will be expected to register for this course. Occasionally this may be the only course for which a student is registered.

NE 8011-2-3, Seminar
1-0-1 each.
Regularly scheduled course required of all major students. Various topics presented by guest speakers, faculty members, and graduate students.

NE 8110-1-2, Special Topics
3-0-3. Prerequisite: consent of School.
Purpose of this course is to permit the Nuclear Engineering Program to offer formal courses on topics of special interest on an ad hoc basis.

NE 8501-2-3, Special Problems
Credit to be arranged. Prerequisite: consent of School.
The student is encouraged to exercise resourcefulness and originality in attacking a problem of special interest to himself or herself and a member of the NE faculty.

NE 8999, Doctoral Dissertation Preparation
Audit only.

NE 9000, Doctoral Dissertation
Credit to be arranged.

HEALTH PHYSICS

HP 2401-2-3. Introduction to Health Physics I, II, III
1-0-1 each.
Prerequisite: sophomore standing.
A course designed to familiarize the student with the health physics profession and the role of the health physicist in industry, medicine, and public health.

HP 4401-2-3. Health Physics Seminar
1-0-1 each. Prerequisite: consent of School.
Intended primarily for students who plan a career in health physics. Review of current literature and current activities in the profession with class discussions.

HP 4411. Radiation Physics
3-3-4. Prerequisites: MATH 2309, PHYS 2123.
This course provides the physical basis for understanding the effects of ionizing radiation on matter, for developing a philosophy of radiation protection for individuals and the environment.

HP 4412. Principles of Health Physics
3-0-3. Prerequisite: PHYS 3001 or HP 4411.
Course emphasizes the biophysical basis of radiation protection and the development of protection criteria.

HP 4413. Applied Health Physics
3-3-4. Prerequisite: HP 4412 or consent of School.
Topics covered include personnel monitoring, biosafety, air sampling and respiratory protection, radiation surveys of nuclear reactors, accelerators, and X-ray installations.

HP 4440. Effect of Nonionizing Radiation and Protection Standards
3-0-3. Prerequisite: consent of School and HP 4412 or equivalent.
A study of methods of production and control of exposure to nonionizing radiations and a review of effects of human exposure and of the radiation protection standards.

HP 4801-2-3-4. Special Problems in Health Physics
Credit to be arranged. Prerequisite: consent of School.
Special problems in health physics will be assigned to students based on their interests and that of a member of the NE&HP faculty. The students are encouraged to exercise resourcefulness and originality in attacking individual special problems.

HP 6401. Radiological Health Physics
3-0-3. Prerequisite: consent of School. Corequisite: PHYS 6101 or equivalent.
An evaluation of radiation protection standards, their development and enforcement. Covers topics such as effects of radiation, internal and external exposure, health physics practice, and dosimetry.

HP 6405. Health Physics Practice
3-0-3. Prerequisite: HP 4413 or 6401 or equivalent.
A review of many types of radiation problems—both basic and applied—relating to the qualifications of a certified health physicist.

HP 6410. Radiation Dosimetry
3-0-3. Prerequisites: HP 6401 and NE 6110, or consent of School.


HP 6414. Radiation Technology Laboratory
2-6-4. Prerequisite: NE 6110.
Advanced laboratory course covering various aspects of radioscopes applications, tracer technology, radiation chemistry, and activation analysis as applied in health physics.

HP 6421. Health Physics Internship
0-9-3. Prerequisite: by special arrangement and consent of School.
Field training for individual graduate students in actual medical diagnostic, therapeutic, or research facilities. May be used as substitute for special problems by students in the medical health physics option. Requires grade project, formal written report, and oral presentation.

HP 6423. Physics of Radiation Therapy
2-3-3. Prerequisite: HP 6410 or consent of School.

HP 6424. Radiation Oncology
2-3-3. Prerequisite: HP 6423 or consent of School.
Description of common tumors, histology, routes of spread, treatment modalities. Methods of tumor localization and treatment planning for external beam, implants, and intracavity sources.

HP 6429. Particle Accelerators
2-3-3. Prerequisite: PHYS 6011 or consent of School.
Principles of particle accelerators including acceleration methods, ion sources and targets, characteristics of machines such as electrostatic generators, betatrons, linear accelerators, cyclotrons, synchrotrons, and synchrocyclotrons. Design and operation of X-ray and neutron generators covered in laboratory.

HP 6430. Radiation Protection in Nuclear Facilities
3-0-3. Prerequisites: HP 6405 or 4413 and NE 6251 or equivalent.
Review of radiation protection requirements at nuclear facilities, radiation monitoring, environmental surveillance planning, and procedures for sample analyses and waste management.

HP 6442. Applied Health Physics Laboratory
1-6-3. Corequisite: HP 6430.
A laboratory course covering practical aspects of monitoring problems in nuclear facilities and environmental surveillance analyses.

HP 6641. Environmental Surveillance and Radioactive Waste Disposal
3-0-3. Prerequisite: consent of School.
Advanced course on environmental radioactivity and environmental aspects of nuclear power. Radioactive waste treatment, reactor effluents, and waste disposal. Identical to HP 6783 but without the laboratory.
measurement of complex aesthetic and mechanical properties of fiber-based systems. New polymers and fibers, new methods of assembling fibers into useful products, and new applications of fibers are continually developing. The School of Textile Engineering prepares students for rewarding careers in the polymer-fiber-textile industry. Graduates obtain positions in manufacturing supervision, technical service, sales, product and process development, research, quality control, and corporate management. They participate in the design, development, manufacturing, and marketing of a broad range of fiber-based and associated products. Many hold key management decision-making positions at a young age.

The textile industry is by far the largest manufacturing industry and employer in the Southeast. If apparel and other associated segments of the industry are included, the textile-based industry is the largest in the United States, representing one out of every eight manufacturing jobs. This is more than five times the number employed in the automobile industry. The textile industry's needs for textile graduates each year far exceed the number of graduates.

Multidisciplinary Programs
See table on page 78.

Curricula
Three study programs are available leading to the degrees Bachelor of Textile Engineering, Bachelor of Science in Textile Chemistry, and Bachelor of Science in Textiles. Students may pursue each degree in a regular four-year program or the five-year cooperative plan.

Because of the multidisciplinary nature of textiles, the curricula stress a broad background. Emphasis in the freshman and sophomore years is on mathematics, chemistry, and physics, and in the junior and senior years on materials science, polymer and textile chemistry, applied mechanics, business administration, and application of each field to the broad range of problems encountered in textiles. All three programs allow the student to select a number of courses from a wide range of general and technical electives.

In place of the many conventional laboratory sessions, textile students participate in student-operated and managed business ventures. Students design, develop, produce, and market novelty textile products. Every participant is exposed to all facets of the business environment.

Since most of the textile course work is concentrated in the last two years of the programs, students from junior colleges and community colleges can readily transfer into selected programs of the School of Textile Engineering.

In addition to campus-wide academic requirements for graduation with a bachelor's degree, the number of quality points earned in textile courses taken toward the degree must be at least twice the number of credit hours in those courses.

Textiles for Other Majors
Students with other majors often enter the textile industry. To further their careers, the School of Textile Engineering has developed coordinated course offerings that will be helpful to students with this goal. Listings of recommended course sequences in textiles are available in the School of Textile Engineering office.

Graduate Program
The School of Textile Engineering offers a graduate program leading to the Master of Science and Doctor of Philosophy degrees. Students holding an undergraduate degree in any one of several fields of science or engineering may qualify for admission. An undergraduate degree in textile engineering, textiles, or textile chemistry is not a specific requirement. Each student pursues an individually structured program.

The graduate course offerings encompass advanced study and research in polymer synthesis, mechanics of fibrous structures, process dynamics, dyeing and dye synthesis, viscoelasticity, experimental design, properties of materials, polymer flow, polymer environmental stability, process control, energetics, and kinetics. The School of Textile Engineering has a variety of active research programs in which students participate.

The School of Textile Engineering is housed in the Hightower Building, a four-story classroom and laboratory facility. The building contains equipment illustrating most major types of textile processing. Well-equipped laboratories are also available for the chemical and physical characterization of polymers, fibers, and fiber assemblies. Specialized equipment is available for fabric flammability studies, polymer environmental stability experiments, fiber-reinforced composite testing, and energy conservation and water pollution studies. Machine shop and instrumentation facilities with full-time supporting technicians are also housed within the building.

Bachelor of Textile Engineering Curriculum

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Textile Engineering
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**Bachelor of Science in Textiles Curriculum**

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### Bachelor of Science in Textile Chemistry Curriculum

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#### Sophomore Year

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#### Senior Year

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1. See “Curricula and Courses of Instruction,” Department of Physical Education and Recreational Services, for full-time students, and for part-time students, for freshmen and sophomores, and for juniors and seniors, respectively. Textile Engineering.

2. Electives must be approved by the Department of Physical Education and Recreation, for full-time students, and for part-time students, for freshmen and sophomores, and for juniors and seniors, respectively. Textile Engineering.

3. See “Curricula and Courses of Instruction,” Department of Physical Education and Recreation, for full-time students, and for part-time students, for freshmen and sophomores, respectively. Textile Engineering.

4. Fifteen hours of electives must be approved by the Department of Physical Education and Recreation, for freshmen and sophomores, and for juniors and seniors, respectively. Textile Engineering.

5. “Curricula and Courses of Instruction,” Department of Physical Education and Recreation, for freshmen and sophomores, and for juniors and seniors, respectively. Textile Engineering.

6. See “Curricula and Courses of Instruction,” Department of Physical Education and Recreation, for freshmen and sophomores, and for juniors and seniors, respectively. Textile Engineering.

7. Fifteen hours of electives must be approved by the Department of Physical Education and Recreation, for freshmen and sophomores, and for juniors and seniors, respectively. Textile Engineering.

8. See “Curricula and Courses of Instruction,” Department of Physical Education and Recreation, for freshmen and sophomores, and for juniors and seniors, respectively. Textile Engineering.

9. “Curricula and Courses of Instruction,” Department of Physical Education and Recreation, for freshmen and sophomores, and for juniors and seniors, respectively. Textile Engineering.

10. See “Curricula and Courses of Instruction,” Department of Physical Education and Recreation, for freshmen and sophomores, and for juniors and seniors, respectively. Textile Engineering.
TEX 2182. Textile Manufacturing Processes III
0-3-1. Prerequisite: TEX 3110 or consent of School. Woven fabric production operations within the student-operated enterprise.

TEX 2500. Survey of Apparel Manufacturing
3-0-3. Apparel engineering and manufacturing from planning and receipt of raw materials to the distribution of finished garments.

TEX 2700. Survey of Polymer and Fiber Technology
3-0-3. Not open to textile students. An introduction to the history, structure, properties, fabrication, and use of polymers in the textile and related industries.

TEX 2701. Textile Industry Survey

TEX 3110. Woven Structures I
3-0-3. Prerequisite: TEX 2104. The weaving processes and woven fabric construction, design, and properties are studied.

TEX 3111. Woven Structures II
3-0-3. Prerequisite: TEX 3110. Dynamics, operating characteristics, and economics of new weaving machines.

TEX 3112. Knit Fabrics
3-0-3. Prerequisite: TEX 2103. A study of warp and weft knit fabric production, properties, and design. Description of knitting machines as related to fabric design and control of properties.

TEX 3113. Nonwoven Fabrics
3-0-3. Prerequisite: TEX 2103. Chemically and mechanically bonded nonwoven fabrics, fabric formation processes, design, and properties.

TEX 3122. Structures of Organic Polymers
3-0-3. Prerequisite: CHEM 1102 or consent of School. A study of chemical and physical structures of organic, fiber-forming polymers and the relationship of their structure to properties.

TEX 3400. Computer Applications in Textiles
2-3-3. Prerequisite: MATH 1712 or 1308 or consent of School. Computer techniques are applied to textile engineering problems. An assembler language introduces FORTRAN. Applications include digital and analog interfaces to textile processes.

TEX 3480. Textile Manufacturing Processes IV
0-3-1. Prerequisite or corequisite: TEX 3112 or consent of School. Knit fabric production operations within the student-operated enterprise.

TEX 3481. Textile Manufacturing Processes V
0-3-1. Prerequisite: consent of School. Evaluation of products produced by the student-operated enterprise.

TEX 3482. Textile Manufacturing Processes VI
0-3-1. Prerequisite: TEX 4305 or consent of School. Fabric finishing operations within the student-operated enterprise.

TEX 3483. Problems in Textile Management I
0-3-1. Prerequisite: MGT 2000, MGT 3300, or consent of School. Methods of plant maintenance and work studies within the student-operated enterprise.

TEX 3484. Problems in Textile Management II
0-3-1. Prerequisite: consent of School. Personnel administration, scheduling, and planning within the student-operated enterprise.

TEX 3485. Problems in Textile Management III
0-3-1. Prerequisite: consent of School. A study of the basic planning and control functions in textile production systems, including design of production facilities, analysis, and control of inventory systems and production planning.

TEX 3486. Dyeing and Printing
3-0-3. Prerequisite: TEX 3112 or TEX 4751 or consent of School. The application of dyes and pigments to fibers, yarns, and fabrics.

TEX 3487. Special Topics
1-0-1 each. Prerequisite: senior standing. A survey of topics of current interest and concern to the textile industry.

TEX 3488. Survey of Fiber Processing

TEX 3700. Survey of Fabric Processing
3-0-3. Not open to textile students. A survey of fabric assemblies including woven, knit, nonwoven, and flexible composite structures. Discussion includes processing, design, and mechanical behavior.

TEX 3701. Survey of Dyeing and Finishing of Textile Materials
3-0-3. Not open to textile students. Dyeing and finishing of textile materials made from natural and synthetic fibers.

TEX 3800. Special Topics
1-0-1. Prerequisite: consent of School. A survey of topics of current interest and concern to the textile industry.

TEX 4100. Textile Management Decision Making
3-3-4. Prerequisite: senior standing. Students practice making management decisions in a competitive market using computer simulations of textile manufacturing operations.

TEX 4101. Planning and Control in Textile Production Systems
3-0-3. Prerequisite: ISYE 3749. A study of the basic planning and control functions in textile production systems, including design of production facilities, analysis, and control of inventory systems and production planning.

TEX 4112. Chemical Structures and Physical Properties of Polymers
3-0-3. Prerequisite: CHEM 1102 or consent of School. The chemical and mechanical properties of fibers are examined and related to end-use performance.

TEX 4200. Fiber Science
3-0-3. Prerequisite: PHYS 2121 or 2111. The physical structure and properties of fibers are examined and related to end-use performance.

TEX 4201. Mechanics of Fibrous Structures I
3-0-3. Prerequisite: TEX 4200 or consent of School. Yarn processing with emphasis on relationships between fiber properties and yarn properties.

TEX 4202. Mechanics of Fibrous Structures II
3-0-3. Prerequisite: TEX 4201 or consent of School. Processes, properties, and mechanics involved in the manufacture of woven and knitted fabrics.

TEX 4203. Mechanics of Fibrous Structures III
3-0-3. Prerequisite: TEX 4201 or consent of School. Investigation of production processes, structures, and properties of adhesive and mechanically bonded nonwoven fabrics and fiber-reinforced materials.

TEX 4300. The Chemistry and Chemical Processing of Fibers and Textiles I
3-0-3. Prerequisite: TEX 4751. The structure and purification of natural and synthetic fibers with emphasis on the relationship of fiber structure and behavior during chemical processing.

TEX 4301. The Chemistry and Chemical Processing of Fibers and Textiles II
3-3-4. Prerequisite: TEX 4751 or consent of School. The dyeing and printing of textile materials with emphasis on the relationship of fiber structure and response of textiles to these processes.

TEX 4302. Textile Finishing Processes
3-0-3. Prerequisite: TEX 4751 or consent of School. The chemical and mechanical finishing of textile materials to impart desired properties with emphasis on the relationship of fiber structure and response of textiles to these processes.

TEX 4305. Chemical Preparation and Finishing of Textiles
3-0-3. Prerequisite: TEX 3122 or TEX 4751 or consent of School. The chemical, thermal, and mechanical processes used in the preparation and finishing of fibers, yarns, and fabrics.

TEX 4310. Textile Instrumental Analysis
2-3-3. Prerequisite: consent of School. The theory and practice of modern instrumental methods as used in the analysis of textile chemicals with emphasis on spectroscopy, chromatography, colorimetry, and differential thermal analysis.

TEX 4401. Introduction to Textile Literature
1-0-1. Sources of textile information and an introduction to search techniques for the textile information system.

TEX 4405-6-7. Seminar
1-0-1 each. Prerequisite: senior standing. TEX 4405 and 4406 are to be taken audit only and are prerequisites for TEX 4407.

Presentations by invited speakers on new developments in textiles, job opportunities, and graduate education.

TEX 4420. Analysis of Textile Materials
3-3-4. Prerequisites: TEX 4200, 3112, or 4751, ISYE 3028, or consent of School. The methods used in the textile industry for assessing the effect of process variables on the end-use performance of textile products are examined.

TEX 4480. Problems in Production Supervision
3-0-3. Prerequisites: TEX 2180-1-2, 3480-1. The methods used in the textile industry for assessing the effect of process variables on the end-use performance of textile products are examined.
TEX 4481. Advanced Problems in Textile Management
0-3-1. Prerequisites or corequisites: TEX 3483-4-5.
Supervision of one of the student-operated enterprise's staff level departments.

TEX 4482. Product Innovation
0-3-1. Prerequisite or corequisite: TEX 4480.
The student is part of a small entrepreneurial team developing new products for the student-operated enterprise.

TEX 4483. Special Problems in Textile Industrial Operations
0-6-2. Prerequisite: TEX 3702 or consent of School.
Available to textile and non-textile students who want to engage in special projects which involve the personnel or facilities of the student-operated enterprise.

TEX 4500. Technology of Carpet Manufacturing
3-0-3.
A study of materials and production systems used in carpet manufacturing. Carpet performance characteristics, dyeing, backcoating, and nonwoven carpet manufacturing methods are examined.

TEX 4502. Fiber-reinforced Materials
3-0-3. Prerequisite: consent of School.
Principles and engineering behavior of flexible and rigid fiber-reinforced composites. Topics include influence of matrix, interface and voids, fabrication, fracture, and fatigue characterization, evaluation of specific composite systems.

TEX 4503. Science of Color
3-0-3. Prerequisite: CHEM 1102, PHYS 2113 or consent of School.
The physical, chemical, and biological principles involved in perception, measurement, and specification of color.

TEX 4504. Fiber Extrusion, Drawing, and Texturing
3-0-3. Prerequisite: TEX 3122, 4751, or consent of School.
Rheology mechanics, energetics, kinetics, phase transitions, and polymer structure in fiber formation by melt, dry, wet and reactive spinning, and drawing and texturing of fibers.

TEX 4505. Structure and Mechanics of Knit Fabrics
3-0-3. Prerequisite: TEX 3112 or consent of School.
The basic geometries of fabrics produced by warp and weft knitting, overall physical properties of knit fabrics, and fabric stress distribution.

TEX 4750. Polymer Science and Engineering I
3-0-3. Prerequisites: CHEM 1102 or CHEM 1112 and PHYS 2123 or consent of School.
An introduction to the chemistry and structure of polymers. Polymerization processes, major polymer systems, and methods of identification of polymers are presented. Also taught as CHE 4750.

TEX 4751. Polymer Science and Engineering II
3-0-3. Prerequisites: CHEM 1102 or CHEM 1112 and PHYS 2123 or consent of School.
An introduction to the physical states and transitions, fabrication processes, and mechanical properties of polymers. Also taught as CHE 4751.

TEX 4753. Survey of Pulp and Paper Technology
3-0-3.
The mechanical systems used in paper manufacture. Chemistry of pulp preparation and nonfibrous additives. Also taught as CHE 4753.

TEX 4760. Polymer Science and Engineering Laboratory
1-6-3. Prerequisites: TEX 4751 or CHE 4751.
Experiments in polymerization, processing, and property evaluation of polymers. Also taught as CHE 4760.

TEX 4773. Paper Formation and Properties
3-0-3. Prerequisite: consent of School.
The processes in the fabrication of paper and paper products from pulp. The effects on paper properties of chemical and mechanical pretreatment of pulp. The measurement of paper properties. Also taught as CHE and ME 4773.

TEX 4800-1-2. Special Topics
3-0-3 each. Prerequisite: consent of School.
Studies of topics of current interest and concern to the textile industry.

TEX 4900-1. Special Problems
3-0-3. Prerequisite: consent of School.
Credit to be arranged. Prerequisite: consent of School.
Special problems involving analytical and/or experimental investigations in the field of textiles.

TEX 6100. Advanced Fiber Science
3-0-3. Prerequisite: graduate standing.
Physical properties, mechanical properties, and microstructure of polymeric fibers are examined and related to end-use performance.

TEX 6101. Textile Testing and Evaluation
3-0-3. Prerequisite: graduate standing.
Study of methods used to characterize properties that are important to the understanding of behavior of fibers, yarns, and fabrics.

TEX 6200. Physical Methods of Investigating Textiles
3-0-5. Prerequisite: ISYE 3028, CHEM 4420, or consent of School.
Study of modern techniques and instrumentation for the evaluation of physical properties of fibers, yarns, and fabrics.

TEX 6201. Process Control in the Textile Industry
3-0-3. Prerequisite: TEX 6200 or consent of School.
Computer techniques are applied to problems in scheduling production equipment and in control of quality, inventories, and production. Topics include interfacing, costs, programming.

TEX 6210. Dynamics of Fiber Processing Systems I
3-0-3. Prerequisites: TEX 6200, 4201 or consent of School.
The dynamic interaction of fibers and fiber assemblies during processing is examined. The effects of fiber and bundle properties on processing variables are analyzed.

TEX 6211-2. Dynamics of Fiber Processing Systems II, III
3-0-3 each. Prerequisite: TEX 6210 or consent of School.
The dynamics of fabric forming mechanisms are examined. Weaving, knitting, sewing, heating, and drying are typical processes which are considered.

TEX 6300. Preparation and Reactions of Polymers
3-0-3. Prerequisites: TEX 4751, 4715.
A detailed treatment of the reactions involved in the synthesis of both man-made and natural polymers including preparative and degradative reactions in polymer systems.

TEX 6320. Fundamental Aspects of Dyeing Processes
3-0-3. Prerequisites: TEX 4301 or 4306, 4751 or consent of School.
Models required for the interpretation of the dyeing behavior of textile materials are examined in order to provide useful semiquantitative descriptions of dye processes.

TEX 6321. Chemical Technology of Stabilization Processes
3-0-3. Prerequisite: TEX 4302 or 4305, 4751 or consent of School.
A comprehensive treatment of finishing processes used in the textile industry to impart desirable end-use performance characteristics to textile materials.

TEX 6400. Information Processes in Textile Science and Engineering
3-0-3. Prerequisite: TEX 3400 or consent of School.
Information aspects of textile science and technology; use of computers in acquisition, processing, and utilization of information and knowledge in textile research and production.

TEX 6750. Polymer Structure and Physical Properties I
3-0-3. Prerequisite: TEX 4751 or CHE 4751 or consent of School.
Morphology and structure, linear and nonlinear viscoelasticity, anisotropic mechanical properties, and yield and fracture behavior of polymers with applications to textile fibers and plastic products. Also taught as CHE 6750.

TEX 6751. Polymer Structure and Physical Properties II
3-0-3. Prerequisite: TEX 4750 or CHE 6750 or consent of School.
A state-of-the-art study of woven, knit, and nonwoven fabric mechanics. Also taught as CHE 7750.

TEX 7751. Energetics
3-0-3. Prerequisite: consent of School.
Energetics applied to polymers and fibers using quasi-Newtonian mechanics, thermodynamics, statistical thermodynamics, and quantum mechanics to relate macroscopic and molecular descriptions of processes and materials.

TEX 7752. Kinetics
3-0-3. Prerequisite: consent of School.
Kinetics applied to polymers and fibers including fluid flow, viscoelasticity, heat transfer, diffusion, electrical conductivity, rates of chemical reactions and phase changes, and irreversible thermodynamics.

TEX 7753. Polymer Flow
3-0-3. Prerequisite: TEX or CHE 6750 or consent of School.
The fluid mechanics, heat transfer, and mixing of non-Newtonian fluids. Experimental methods for characterizing fluids and the extrusion of polymer melts are emphasized. Also taught as CHE 7753.

TEX 7999. Preparation for Doctoral Qualifying Exams
TEX 8003-4-5. Seminar
1-0-1 each. Audit only.

TEX 8100-1-2. Special Topics in Textile Science and Engineering
3-0-3 each. Prerequisite: consent of School.
Topics of current interest in textile science and engineering.

TEX 8500-1-2. Special Problems in Textiles and Textile Engineering
Credit to be arranged.

TEX 9000. Doctoral Thesis

Established in 1969, School in 1948,
Department in 1934,
School of Commerce in 1913

Dean—Gerald J. Day; Assistant Deans—Andrew J. Cooper III, Marilu H. McCarty;
Callaway Professor—Eugene E. Comiskey;
Mills B. Lane Professor—Bernell K. Stone;
Regents' Professor Emeritus—Sherman F. Dallas; Professors—Philip Adler, Jr., Fred C. Allvine, William Carl Biven, Robert W. Carney, Kong Chu, Robert Earl Green,
Robert G. Jeroslow, Ferdinand K. Levy, Mack A. Moore, Roderick F. O'Connor,
Leonard J. Parsons, William A. Schaffer, Matthew J. Sobel, Fred A. Tarpley, Jr.;
Associate Professors—Andrew J. Cooper III, Gerald J. Day, David M. Herold, John R. Kaatz, Jackie Kleiner, Naresh K. Malhotra, David C. Nachman, Peter G. Sassone,

General Information
The College of Management provides education of the highest possible quality to prepare students for careers as managers or for additional study at the graduate level. The increasing number of organizations and the growing complexity of modern industrial and government operations have resulted in a great need for college graduates with formal preparation in management and economics.

Georgia Tech's College of Management concentrates on preparing students for meeting long-range career objectives rather than developing specific job knowledge.

The College of Management offers three undergraduate programs leading to the Bachelor of Science in Management, the Bachelor of Science in Management Science, and the Bachelor of Science in Economics. All three degree programs follow a common core curriculum with only minor exceptions. However, each program allows sufficient flexibility for the student to develop and follow his or her own educational goals.

Problem solving takes place in a complex technical, social, and political environment. Students can sharpen the basic tools of management and economics by understanding the natural, life, and social sciences, exploring the environment of the business enterprise, and gaining knowledge of the internal activities of the enterprise itself. Thus, every student is required to take substantial course work in laboratory science, humanities, and social science. Students become familiar with the fundamental activities of management by taking courses such as accounting, economics, computer applications, marketing, production, and finance.

Graduate work in the College leads to the Master of Science and the Doctor of Philosophy in Management.
program to his or her individual educational objectives. Students may take a concentration of electives in such areas as organizational behavior, finance, accounting, computer applications, marketing, industrial relations, and general management.

Curriculum

Freshman Year

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<tr>
<th>Course</th>
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Sophomore Year

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Economics

Among the complex problems facing society today, economic issues stand in the forefront. In response to rapidly changing economic conditions, the public has become increasingly concerned with issues such as full employment, price stability, economic growth, adaptation to technological advances, efficiency in the management of complex industrial organizations, and international prosperity. The program in economics, based on the management core, enables students to analyze complex economic problems and to understand policies for their solutions.

Bachelor of Science in Economics

Modern economics is analytically rigorous. The curriculum for this option prepares the student to cope with the advances that have been made in this field of study. The program requires a background in mathematics, statistics, and economic theory.

A degree in economics is suitable for students who wish to major in an academic discipline at the undergraduate level. Students also obtain professional management training through the electives courses in management. The degree in economics provides an excellent background for graduate work in economics, other social sciences, or management.

Freshman Year

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Curricula and Courses of Instruction
Bachelor of Science in Management Science

Students who possess strength and interest in applying mathematics to managerial problems will benefit from the management science program at Georgia Tech. The program, based upon a foundation of applied mathematics and the institutional aspects of the modern business, develops analytic modes organized to allocate resources within the firm. The curriculum also contains a three-course sequence of specialization which permits the student either to concentrate in an applied area or to strengthen his or her theoretical foundation.

Graduates of the option will typically be employed as staff analysts in industry and government, as systems analysts, or in a wide variety of positions where a high degree of analytic ability is required. The program also provides a strong base for graduate study in business, economics, management science, operations research, information systems, and related areas.

Curriculum

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<th>Freshman Year</th>
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Statistics for Management Science  5-0-5

MGT 4200  
Industrial Relations  3-0-3

Elective a  
Organization Behavior  3-0-3

MGT 3600  
Finance  3-0-3

MGT 3300  
Marketing I  3-0-3

ECON 3100  
Econometrics  3-0-3

Elective  
Marketing  3-0-3

MGT 3070  
Management Science  
Models in Finance  3-0-3

ENGL 3015  
Public Speaking  3-0-3

MGT 4550  
Production Management  3-0-3

Total Credit Hours: 45

Senior Year

Course  Credit Hours

Elective a  Management Science Concentration  9

Elective a  Advanced Mathematics  6

Elective a  Specialization or Project  9

Electives  Free  18

MGT 4195  
Integrated Management Problems  3

Total Senior Year  45

Graduate Programs

The College of Management offers graduate programs leading to the Master of Science in Management (M.S.M.), the undesignated Master of Science, and the Doctor of Philosophy.

The M.S.M. program, which is accredited by the American Assembly of Collegiate Schools of Business, provides a professional management education for students with baccalaureate degrees in any discipline. Calculus is the only prerequisite. For students who want to review and sharpen their mathematical skills, a three-week, intensive review course is offered immediately before each fall quarter.

The M.S.M. program comprises twenty-four courses (nearly seventy-two hours), fifteen of which are required. These fifteen courses form a common core of knowledge required of all M.S.M. students. The remaining nine elective courses provide considerable flexibility for students to build competence in one or more concentration areas. This freedom permits each student to fashion a unique curriculum directed towards individual educational and career goals.

Available concentration areas include accounting, economics, finance, general management, management science, marketing, organizational behavior (including human resource management), and production and operations management.

Entry is in the fall quarter and the typical course load is four courses per quarter. Most of the common core is completed in the first academic year. Students with appropriate backgrounds are encouraged to substitute suitable advanced courses for some basic core requirements. Since summer course work is minimal, the College encourages students to gain relevant work experience during the summer between the first and second years of the program. Only three required courses are scheduled in the second year so that students can devote most of the year to concentration area(s) and electives.

The undesignated Master of Science degree program serves students whose educational and career goals may not be best served by the M.S.M. program. Under these circumstances, the student can pursue a master's level curriculum specifically designed for his or her individual needs. The student and an academic adviser determine the course requirements for such a curriculum. The Master's Committee of the College of Management must approve individually designed programs in advance.

The doctoral program in the College of Management complements and reflects the technological emphasis of the Institute.

All doctoral students take comprehensive examinations, which include both a general and a special examination. The student becomes a candidate for the degree after successful completion of both exams and the approval of the prospectus of his or her dissertation. On completion of the dissertation, the student must take a final oral examination as prescribed in the general regulations of the graduate division.

Program in Statistics

For information concerning the graduate program in statistics, refer to page 126.

Courses of Instruction

ECONOMICS


The behavior of economic units in pricing and output decisions.


Survey of national income, employment, money and banking, and international trade. Relates consumer, business, government, and international sectors to the aggregate economy.


Intermediate price theory with applications to management problems.


An intermediate macroeconomic theory course to enable the student to analyze the national economic environment relative to the firm and stabilization of the national economy.

ECON 3002. Money and Banking  3-0-3. Prerequisites: ECON 2000-1.

An analysis of how money fits into the economic system and the problems of administering monetary policy both domestically and internationally.


Topics for discussion will be chosen to encourage the student to focus understanding of economic theory on a substantive problem. Designed for economics majors.

ECON 3100. Econometric Methods I  3-0-3. Prerequisite: MSCI 3111.

An introduction to the statistical methods for estimating the quantitative relationships among economic variables. Topics include model specification, parameter estimation, prediction, and verification.


The forces, unique characteristics, and problems associated with American industrialization.

ECON 3401. European Economic History  3-0-3. Prerequisites: ECON 2000-1.

An economic survey of the major institutions, inventions, the agricultural revolution, and the industrial revolution in Europe.


General theories of economic development. Each student will be required to analyze the economy of a developing country.


The logical structure of scientific theory as it applies to knowledge about political and economic situations and events.


A theoretical perspective to explain and predict the effects of actual and proposed public policy and to generate some standards of evaluation.

ECON 4000. Topics in Advanced Microeconomics  3-0-3. Prerequisites: ECON 3000-1.

Selected topics in advanced microeconomics. Designed for economics majors.

ECON 4050. Monetary Theory and Policy  3-0-3. Prerequisite: ECON 3001.

The behavior of interest rates, the structure of financial markets, aspects of various financial institutions, and issues in monetary policy.


Emphasizes the application of mathematical tools to economic analysis. Topics include static analysis, comparative-static analysis, optimization, and dynamic analysis.


Cyclical fluctuations in the total economy are examined empirically. Methods of making forecasts of national and industry performance are presented.

ECON 4230. Economics of the Labor Market  3-0-3.

The application of microeconomic theory to wages, employment, and productivity.

ECON 4231. Labor History  3-0-3.

A survey of the times and conditions facing the working class in attempting to establish a body of industrial jurisprudence.
ECON 4235. Protective Labor Legislation 3-0-3  Federal and state regulation of worker security against occupational injury, unemployment, old-age, disability and discrimination, plus wage and hour legislation.

ECON 4265. Labor Relations Law 3-0-3  Prerequisite: MGT 4200. An examination of labor legislation, court decisions, and NLRB rulings on labor-management relations.

ECON 4300. International Economics 3-0-3  Prerequisites: two of ECON 2000-1. Foreign trade and commercial policy, international finance, and current problems of international economic relations.

ECON 4310. Public Finance 3-0-3  Prerequisite: ECON 3000. Analyzes government's role in resource allocation, income distribution, stabilization and growth through the economic effects of government spending and revenue-raising activities.

ECON 4320. Managerial Economics 3-0-3  Prerequisite: ECON 3000. Relationships between economic concepts and managerial decisions. Topics covered include nonprofit goals of the firm, unstructured managerial decisions.

ECON 4330. Regional Economics 3-0-3  Prerequisites: ECON 2000-1. Theories of regional income determination and regional growth, spatial economic structure, central-place theory, and regional effects of public policy.

ECON 4335. The Economics of Environmental Quality 3-0-3  Prerequisites: ECON 6000 and 6410. Topics included are the causes of market failure to provide a high-quality environment, amenity resources, and extra-market values.

ECON 4410. Industrial Development in Latin America 3-0-3  Prerequisites: ECON 2000-1. The principles of industrial development in emerging nations. The student prepares an analysis of the problems in a specific Latin American country.

ECON 4420. Comparative Economic Systems 3-0-3  Prerequisites: ECON 2000-1. A critical study is made of the methods by which various economic systems resolve fundamental problems in production, exchange, distribution, and capital formation.


ECON 4501. Political Economy: Nonmarket Decision Processes II 3-0-3  The economics and politics of change, technological progress, price effects on innovation, and trade-offs between economic efficiency and political expediency in national policies for energy, research, etc.

ECON 4801-2-3-4-5. Special Topics in Economics 3-0-3 each. A course designed to permit students to pursue a specialized interest in an area of economics not extensively treated in the offerings of the College.

ECON 4811-2-3-4-5. Special Topics in Economics 1-0-1 through 5-0-5 respectively. Courses designed to permit students and a professor to pursue a specialized interest in an area of economics not extensively treated in the offerings of the College.

ECON 4900. Georgia Internship Program Credit to be arranged. Designed to permit independent study with a faculty member. To register, the student must obtain written approval of the associate dean and of the sponsoring professor.

ECON 4901-2-3. Individual Research in Economics Credit to be arranged. Designed to permit independent study with a faculty member. To register, the student must obtain written approval of the associate dean and of the sponsoring professor.

ECON 4990. Georgia Internship Program Credit to be arranged. Designed to permit independent study with a faculty member. To register, the student must obtain written approval of the associate dean and of the sponsoring professor.

ECON 6000. Economic Analysis for Management I 3-0-3  Prerequisite: consent of College. An intensive treatment of economic concepts which enables the prospective manager to understand the economic environment within which firms operate.

ECON 6001. Economic Analysis for Management II 3-0-3  Prerequisite: consent of College. Topics in economic analysis oriented to provide a framework for contemporary management.

ECON 6050. Money and Capital Markets 3-0-3  Prerequisite: ECON 6000. The functions of and relationships between various financial markets and institutions, the behavior of interest rates, and the impact of monetary policy on financial markets.

ECON 6120. Economic Forecasting 3-0-3  Prerequisite: ECON 6001. Macroeconomic theory and the analysis of overall economic conditions with their application to management decisions.

ECON 6230. Collective Bargaining 3-0-3  Prerequisite: previous course in labor relations. Case course involving contract negotiations, grievance handling, and arbitration.

ECON 6266. Wage and Employment Theory 3-0-3  Prerequisites: ECON 6000, 6001. An analysis of the economic theories and institutional developments explaining the terms, conditions, and levels of employment.

ECON 6300. International Trade and Finance 3-0-3  Prerequisite: ECON 6001. Foreign exchange market, foreign trade and commercial policy, international finance and current problems of international economics.

ECON 6320. Managerial Economics 3-0-3  Prerequisite: ECON 6000. Relationships between economic concepts and managerial decisions. Topics covered include nonprofit goals of the firm, unstructured managerial decisions, and the determinants of good managerial decisions.

ECON 6330. Regional Economics 3-0-3  Survey of the economics of regions, emphasizing regional delineation, systems of cities, measurement of regional activity, theories of income, employment, and economic growth.

ECON 6331. Economics of Industrialization 3-0-3  An examination of long-run growth processes seeking causes of underdevelopment, exploring theories of economic growth, and applying these explanations to developed and underdeveloped economies.

ECON 6335. The Economics of Environmental Quality 3-0-3  Prerequisite: consent of the College. Topics included are the causes of market failure to provide a high-quality environment, amenity resources, and extra-market values.

ECON 6410. Development of Economic Thought 3-0-3  Prerequisites: ECON 6000-1, consent of College. Development of the various schools of economic thought and their contributions to the present body of economic theory. Credit not given for both ECON 6400 and 6410.

ECON 6750. The Changing Economy 3-0-3  This course examines the long-run forces within the economy that support economic growth and rising standards of living. Studies the changes in these sources of growth due to the recent performance of the economy.

ECON 6760. Financial Management and Economics of Nuclear Power 3-0-3  Interdisciplinary relationship of the nuclear fuel cycle and reactor system to the electrical power industry treated as a system, effect of management decisions on the overall economics. Also listed as NE 6760.

ECON 7000. Master's Thesis Credit to be arranged. Designed to permit independent study with a faculty member. To register, the student must obtain written approval of the associate dean and of the sponsoring professor.

ECON 7010. Advanced Microeconomic Analysis 3-0-3  Prerequisite: consent of College. An analysis of consumer and firm decision making in order to facilitate model building of individual choice processes.

ECON 7011. Seminar in Microeconomics 3-0-3  Prerequisite: consent of College. Interrelationships among the major aggregated sectors of a national economy taking special cognizance of institutions which exist in the U.S.

ECON 7020. Advanced Macroeconomic Analysis 3-0-3  Prerequisites: ECON 7010 and consent of College. Students have an opportunity to pursue in depth some topic or problem in the area of macroeconomics.

ECON 7021. Seminar in Macroeconomics 3-0-3  Prerequisites: ECON 7011 and consent of College. Students have an opportunity to pursue in depth some topic in the area of macroeconomics.

ECON 7100. Econometrics 3-0-3  Prerequisite: consent of College. Advanced treatment of the specification, estimation, forecasting, and policy evaluation of both static and dynamic managerial models. Techniques, applications, and problems associated with both single equation and simultaneous equation models are included.
ECON 7101. Seminar in Econometrics
3-0-3. Prerequisites: ECON 7100 and consent of College
Empirical economic research.

ECON 8401-2-3-4-5. Special Topics
1-0-0 through 6-0-6. Prerequisite: consent of College.
Topics of current interest in the field of economics.

ECON 8501-2-3-4. Special Problems
Credit to be arranged. Prerequisite: consent of College.
Provides project work experience in the field of economics.

ECON 9000. Doctoral Thesis

MANAGEMENT

MGT 2000. Accounting I
3-0-3. Prerequisite: sophomore standing.
Provides a general understanding of financial accounting systems and interpretation of financial reports.

MGT 2001. Accounting II
3-0-3. Prerequisite: MGT 2000.
Provides a general understanding of cost accounting systems with emphasis on the manufacturing situation.

MGT 2002. Accounting III
Provides a general understanding of management applications of accounting output in a decision context.

MGT 3010. Taxation
3-0-3. Prerequisite: MGT 2000.
Business income tax requirements and the management planning necessitated by various tax alternatives. Some attention to personal income taxes.

MGT 3020. Accounting Theory and the Analysis and Interpretation of Financial Statements
4-0-4. Prerequisite: MGT 2002.
Accounting techniques and principles for measuring assets, equities, and earnings of manufacturing and financial corporations. Includes revenue recognition, inventory valuation, and accounting theory, etc.

MGT 3021. Topics in Managerial Accounting and Control
3-0-3. Prerequisites: MGT 2002 and MSCI 3100.
Advanced topics in managerial reporting and analysis such as divisional performance measurement, capital budgeting under uncertainty, budgeting, control, and other issues in internal resource allocation.

MGT 3050. Computer-based Management Systems
3-0-3. Prerequisite: MSCI 2000.
An introduction to concepts used in the design of management systems relying on computers and information technology.

MGT 3060. Finance I
3-0-3. Prerequisite: ECON 2000, MGT 3001 and MSCI 3100 or an equivalent statistics course.
Introduction to financial analysis, financial planning, and working capital management.

MGT 3061. Finance II
3-0-3. Prerequisite: MGT 3060.
Application of capital budgeting techniques to the firm, including selection from alternative investment opportunities, determining cost of capital, and treatment of uncertainty.

MGT 3070. Management Science Models in Finance
3-0-3. Prerequisite: MGT 3060.
A study of the analytical techniques in finance including capital budgeting, portfolio theory, and capital market theory.

MGT 3080. Investments
3-0-3. Prerequisite: MGT 3060.
The theory and practice of security analysis and portfolio management as applied to stocks and bonds.

MGT 3090. Commercial Bank Management
3-0-3. Prerequisite: MGT 3060 or permission of instructor.
Contemporary problems and practices of managing banks and related institutions, including asset and liability management, loan and liquidity management, and aspects of regulation.

MGT 3100. Organizational Development
3-0-3.
Analysis of the structural development of the organization. Particular emphasis is given to organization-environment interfaces, effectiveness, and efficiency. Managing technology and change.

MGT 3150. Management Theory
3-0-3. Prerequisites: MGT 2002 and ECON 2000 and 3000.
Provides students with a fundamental management theory matrix essential to the understanding of management process, and role.

MGT 3161. Management as a Creative Force
3-0-3.
Describes the manager's role in accomplishing the entrepreneurial mission of the enterprise. Each student analyzes the reports on an existing organization.

MGT 3260. Business Law I
3-0-3.
Development and function of the law, court organization, procedure and substantive law in contracts, business organizations, and agencies.

MGT 3261. Business Law II
3-0-3.
Legal problems encountered in an urban environment with a socioeconomic and political atmosphere, specifically in the areas of consumer protection, bankruptcy, and constitutional law.

MGT 3300. Marketing I
3-0-3. Prerequisite: ECON 2000.
Marketing's role in productive process, basic buyer behavior, market segmentation, consumer behavior, management of marketing activities, and environmental influences on marketing management.

MGT 3301. Marketing Management
3-0-3. Prerequisite: MGT 3300.
Emphasis on marketing management problems through the process of analysis, planning and control, case analysis, and readings.

MGT 3310. Management Research
3-0-3. Prerequisites: MGT 3300, MSC1 3100.
Research orientation, planning an investigation, questionnaires, sampling, interpretation of results, report presentation, and computer-assisted research.

MGT 3320. Management Science Models in Marketing
3-0-3. Prerequisites: MGT 3300, MSCI 3100, MSCI 3400.
The use of management science models to solve marketing management problems. Application rather than theory is stressed.

MGT 3330. Contemporary Issues in Marketing
3-0-3. Prerequisite: MGT 3300.
Course is designed to encourage students to examine the principles of marketing in light of contemporary thinking concerning social, economic, and Technological development.

MGT 3700. Analysis of Financial Data
4-0-4. Not open to College of Management undergraduates.
A survey of general and cost systems. Emphasis on the use of accounting data. Credit not given for MGT 3700 and any other undergraduate accounting course.

MGT 4022. Problems in Financial Reporting
3-0-3. Prerequisite: MGT 3060.
Problems in certifying financial statements, including selection from alternative investment opportunities, determining cost of capital, and treatment of uncertainty.

MGT 4024. Seminar in Financial Reporting and Control
4-0-4. Prerequisite: MGT 3020.
Consolidations, funds statements, earnings per share, results of operations, mergers and pooling, general price level adjustments, foreign exchange transactions, and not-for-profit organizations.

MGT 4026. Auditing Concepts
4-0-4. Prerequisite: MSC1 3100 and MGT 3200.
Auditing, whether the design of accounting systems and external and internal auditing and control procedures.

MGT 4110. The Management of Organized Effort
3-0-3. Open only to seniors.
Analyses as a partial consideration of developing and controlling situations toward which people act and respond, both individually and as members of groups.

MGT 4115. Contemporary Management Thought
3-0-3. Prerequisite: MGT 3150 or consent of College.
This course emphasizes the impact of changing social values on management thought and practices. Guest speakers make important contributions to the course.

MGT 4120. Contemporary Research in Management
3-0-3. Prerequisite: either MGT 3100, 4100, or consent of College.
Investigations, analyses, critiques, and reports of current research orientations in management. Students learn how management research is done.

MGT 4140. Personnel Management Problems
3-0-3. Prerequisite: MGT 3150 or consent of College.
Analysis of the personnel management process with emphasis placed upon the role and contribution to the firm of the staff function of personnel administration.

MGT 4151. Management of Industrial Research and Development Programs
3-0-3. Normally taken by seniors.
Covers the broad aspects of international business, policies of the U.S. in world markets, various types of international business transactions, and the relationship of business to economics, politics, culture, and government interaction.

MGT 4160. Management Concepts and Issues in World Business
3-0-3. Normally taken by seniors.
Covers significant aspects of international business, changing patterns of world industry, emergence of common markets, role of U.S. industry overseas.

MGT 4165. Seminar
1-0-1.
Junior standing.
Lectures and discussions with prominent business, government, labor, and educational leaders. Offered winter quarter only.

MGT 4170. Career Analysis
3-0-3. Seniors only.
A course designed to enable students to analyze classified jobs in a company to determine career paths, training provided, and counseling for workers.

MGT 4180. Industrial Management Honors Seminar
3-0-3. Last or next to last quarter seniors by faculty invitation.
Gives outstanding seniors an opportunity to research, analyze, and discuss current management and economic problems.
MGT 4195. Integrated Management Problems 3-0-3. Prerequisites: senior standing and MGT 3150, 3300, a marketing elective, MGT 3061 or 3070, and 4350. Comprehensive cases are used to integrate knowledge at the policy level of management and to relate management decisions to the economic and competitive forces affecting business.

MGT 4200. Industrial Relations 3-0-3. Theories of the labor movement, union-management relationship, including the legal setting, contract negotiations, contract administration, and the roles and nature of third parties.


MGT 4202. Cases in Labor-Management Relations 3-0-3. Prerequisite: MGT 4200. A case study of problem areas in union-management relations. The cases used will be actual (NLRB) and labor arbitration decisions.

MGT 4250. Nonmarket Environment of the Firm 3-0-3. Open only to seniors. An examination of the sociocultural factors which must be taken into account in the management decision process and of the forces which lead to their change through time.

MGT 4290. Public Administration 3-0-3. An examination of the managerial function of federal, state, and local governments with emphasis on the role of their interaction with the private sector.

MGT 4331. Consumer Behavior 3-0-3. Prerequisite: MGT 3300. Stresses the impact of buyer decisions on the firm's marketing functions. Discusses economic, psychological, sociological, anthropological, and organization impacts on buyer decisions.

MGT 4335. International Marketing 3-0-3. Prerequisite: MGT 3300. Emphasis on international comparative analysis, the role of marketing in economic development, and marketing strategies and policies of multinational firms.

MGT 4350. Production Management 3-0-3. Prerequisites: GGT 3150, MSCI 3400. The organizational, economic, and physical setting in which production occurs. Methods to analyze and improve production processes and service operations.

MGT 4801-2-3. Special Topics in Industrial Management 3-0-3 each. Permits groups of students and a professor to pursue areas of management not extensively treated in other courses.

MGT 4811-2-3-4-5. Special Topics in Management 1-0-1 through 5-0-5 respectively. Permits a group of students and a professor to pursue areas of management not extensively treated in other courses of the college.

MGT 4901-2-3. Individual Research in Industrial Management Credit to be arranged. Designed to permit independent study with a faculty member. To register, the student must obtain the written approval of the associate dean and of the sponsoring professor.

MGT 4990. Internship Program Credit to be arranged. Prerequisite: consent of College. Broadens the scope of the college curriculum by offering students a community-based learning experience which stresses the completion of a specific task.


MGT 6001. Managerial Accounting 3-0-3. Prerequisite: MGT 6000 and consent of College. Introduction to cost and managerial accounting. Topics include basic cost concepts, costing systems, cost-volume-profit analysis, and the general role of accounting data in planning, control, and decision making.

MGT 6020. Accounting Theory and the Analysis and Interpretation of Financial Statements 4-0-4. Prerequisite: MGT 6000. Accounting techniques and principles of measuring assets, equities, and earnings of manufacturing and financial corporations. Includes revenue recognition, inventory valuation, accounting theory, etc.

MGT 6021. Topics in Managerial Accounting and Control 3-0-3. Prerequisites: MGT 6001 and consent of College. Advanced topics in managerial reporting and analysis, such as divisional performance measurement, capital budgeting under uncertainty, budgeting, control, and other issues in internal resource allocation.

MGT 6022. Financial Reporting 4-0-4. Prerequisite: MGT 6020. Consolidations, funds statements, earnings per share, results of operations, mergers and pools, general price level adjustments, foreign exchange transactions, and not-for-profit organizations.


MGT 6024. Financial Reporting and Control 4-0-4. Prerequisite: MGT 6022. An in-depth study of two major current issues in accounting, involving controversy and a significant possibility of substantial impact on theory and practice.

MGT 6025. Socioeconomic Accounting 4-0-4. Prerequisite: MGT 6001. Use and limitations of accounting analysis in defining and measuring the economic costs, benefits, and effectiveness of public projects and not-for-profit organizations.

MGT 6040. Auditing Concepts 4-0-4. Prerequisite: MGT 6001. Problems in certifying financial statements, including audit objectives, statistical approaches to audit scope, and auditing complex computerized data systems.

MGT 6041. Taxation and Decisions 4-0-4. Prerequisites: ECON 6000, 6001, and MGT 6000, or consent of College. A comprehensive examination of the major provisions of the Internal Revenue Code. Emphasis is placed upon the impact of taxes on business decisions.

MGT 6060. Financial Management I 3-0-3. Prerequisites: graduate standing and MGT 6000. Modern finance emphasizing concepts useful to the nonfinancial manager. Financial statement analysis, financial projections and forecasting, time value, cost of capital, capital budgeting, risk and valuation.


MGT 6063. Corporate Cash Management and Banking Relations 3-0-3. Prerequisites: MGT 6061, MSCI 6022. Daily cash management, short-term securities, cash planning, cash forecasting, credit lines, short-term financing, banking relations, collection systems, credit policy, and other aspects of the corporate treasurer's job.


MGT 6065. Seminar in Financial Management 3-0-3. Prerequisite: MGT 6061. Topics of current interest in the field of financial management.

MGT 6080. Investments I 3-0-3. Prerequisite: MGT 6060. The theory and practice of security analysis and portfolio management as applied to stocks and bonds.

MGT 6081. Investments II 3-0-3. Prerequisite: MGT 6080. A continuation of MGT 6080. Includes advanced topics in portfolio theory and detailed study of bonds, options, and futures contracts.

MGT 6090. Commercial Bank Management 3-0-3. Prerequisite: MGT 6080 or permission of instructor. The analysis of management problems of commercial banks, including the loan, investment, deposit, and capital functions and the interrelationships between them.


MGT 6103. Compensation and Jobs 3-0-3. Prerequisite: MGT 6101. Concepts and procedures used for compensating managerial and non-managerial personnel.

MGT 6104. Attraction, Selection, and Development of Human Resources 3-0-3. Prerequisite: MGT 6101. Advanced study of legal, statistical, and theoretical issues in the development of effective human resource policies.

MGT 6105. Individuals in Organizations 3-0-3. Prerequisite: MGT 6100. Discussion and application of theories involving individual behavior in organizations.

MGT 6106. Group Processes in Organizations 3-0-3. Prerequisite: MGT 6100. A treatment of factors affecting the design of effective complex organizations.

MGT 6140. Management Systems Analysis
3-0-3.
An analysis of the environmental factors and forces that interact to form systems and their resultant impact upon the practice of management.

MGT 6155. Development of Management Thought
3-0-3.
A survey of the development of management thought based upon a critical examination of classic works in management literature.

MGT 6160. Management Theory
3-0-3. Prerequisite: consent of College.
Provides resources essential to the development of a matrix of management theory at the professional level.

MGT 6175. Entrepreneurial Management
3-0-3. Prerequisite: MGT 6000.
The manager’s role in building or restructuring enterprises. Students interact with entrepreneurs in and out of class and write a report on a growing firm.

MGT 6180. Multinational Business
3-0-3. Prerequisite: consent of College.
Critical examination of business concepts, organizational structures, and control processes of the multinational corporation in different political and economic environments.

MGT 6195. Managerial Policy I
3-0-3. Prerequisites: MGT 6001, 6100, ECON 6000, and two of MGT 6001, 6060, 6300, 6350.
Economic, competitive, and governmental forces affecting the formulation of corporate strategy and managerial policies and decision making.

MGT 6196. Managerial Policy II
3-0-3.
An examination of selected strategic issues, problems, and competitive strategies in particular industries and types of organizations, combined with field projects and guest lectures.

MGT 6200. Labor Problems
3-0-3.
An examination of the union-management relationship. Includes analysis of labor agreement, grievance procedures and arbitration, and the legal environment of labor relations.

MGT 6260. The Legal Environment
3-0-3.
The role of law in society, legal philosophy, and basic legal concepts.

MGT 6300. Marketing Management I
3-0-3.
Critical analysis of the marketing functions of an industrial enterprise, organizing and control of marketing programs emphasized.

MGT 6301. Marketing Management II
3-0-3. Prerequisite: MGT 6300.
Advanced course in marketing analysis and strategy formulation. Particular emphasis will be given to application of materials from MGT 6300.

MGT 6302. Buyer Behavior
3-0-3. Prerequisite: MGT 6500.
This course exposes students to behavioral science concepts and approaches of relevance in describing, understanding, and predicting the behavior of consumers.

MGT 6303. Sales and Promotion Management
3-0-3. Prerequisites: MGT 6300, MGT 6301.
Advertising, personal selling, sales promotion aids, channel marketing, consumer integration, and other communication tools as variables in the overall promotional mix.

MGT 6305. Strategic Market Planning
3-0-3. Prerequisites: MGT 6300, MGT 6301.
Integrates marketing planning into the strategic planning process. Focuses on new concepts and techniques which facilitate market analysis and the development of strategic plans.

MGT 6310. Marketing Research and Analysis
3-0-3. Prerequisite: MGT 6300.
Theory and techniques of marketing analysis and its use in the formulation of policy and strategy.

MGT 6315. Marketing Analysis
3-0-3. Prerequisites: MGT 6300, MGT 6310.
This course seeks to impart an understanding of the various techniques useful for analyzing and interpreting marketing research data.

MGT 6320. Marketing Models
3-0-3. Prerequisites: MGT 6300 and a knowledge of probability and statistics.
Marketing models utilizing probability and statistics as well as behavioral techniques.

MGT 6330. Consumerism and Public Policy Issues in Marketing
3-0-3. Corequisite: MGT 6300.
Recent issues in consumerism, the performance of marketing activity within our society.

MGT 6350. Production and Operations Management I
3-0-3. Prerequisite: MGT 6200 or equivalent. Corequisites: MGT 6022 or equivalent.
Processes and management of production of goods and services. Methods to analyze, improve, and plan production. Case studies.

MGT 6351. Production and Operations Management II
3-0-3. Prerequisite: MGT 6350.
Combination of MGT 6350 with more emphasis on computer models.

MGT 6750. The Changing Economy
3-0-3.
This course examines the long-run forces within the economy that support economic growth and rising standards of living. Studies the changes in these sources of growth due to the recent performance of the economy.

MGT 7000. Master’s Thesis
3-0-3.

MGT 7750. Seminar on Psychology and Management
3-0-3. Prerequisites: PSY 6601 or 6609, MGT 6150 or 6105, and consent of College.
Selected management problems involving psychological complexities, individual behavior in an organizational setting. Also listed as PSY 7750.

MGT 8401-2-3-4-5-6. Special Topics
1-0-1 through 6-0-6 respectively. Prerequisite: consent of College.
Topics of current interest in the field of management.

MGT 8501-2-3-4. Special Problems
Credit to be arranged. Prerequisite: consent of College.
Provides project work experience in the field of management.

MGT 8801-2-3-4-5-6. Special Topics
Credit to be arranged.
Topics of current interest in the field of management.

MGT 8801-2-3. Prerequisite: MGT 8400 or 3200.
Additional applications of linear programming to analysis of management decision problems. Topics include alternatives to the simplex algorithm and special applications.

MGT 8801-2-3. Prerequisite: MGT 8400 or 3200.
Introduction to the theory and applications of dynamic, integer, and non-linear programming in the formulation of management decision problems.

MGT 8801-2-3. Prerequisite: MGT 8400 or 3200.
Analytical and simulation approaches to the analysis of queueing and inventory systems.

MSCI 4801-2-3-4. Special Topics in Management
3-0-3 each. Normally taken by seniors.
Designed to permit students and a professor to pursue a specialized interest in an area of management science not extensively treated in the offerings of the college.

MSCI 4811-2-3. Special Topics in Management Science
1-0-1 through 3-0-3. Prerequisite: MATH 1711.
This second course in the methodology and application of management science is programmed with the use of stochastic models in the analysis of managerial and economic decision making.

MSCI 3300. Decision Analysis in Management
3-0-3. Prerequisite: MATH 1711.
An introduction to decision models for management situations under risk and uncertainty including fundamental economic concepts of a theory of rational choice.

MSCI 3400. Analytical Methods in Management I
3-0-3. Prerequisite: MATH 1711.
Introduction to linear programming. Emphasis on formulation of problems encountered in professional practice and on interpretation of solutions.

MSCI 3401. Analytical Methods in Management II
3-0-3. Prerequisite: MSCI 3400 or 3200.
Additional applications of linear programming to analysis of management decision problems. Topics include alternatives to the simplex algorithm and special applications.

MSCI 3402. Analytical Methods in Management III
3-0-3. Prerequisite: MSCI 3400 or 3200.
Introduction to the theory and applications of dynamic, integer, and non-linear programming in the formulation of management decision problems.

MSCI 3300. Decision Analysis in Management
3-0-3. Prerequisite: MATH 1711.
An introduction to decision models for management situations under risk and uncertainty including fundamental economic concepts of a theory of rational choice.

MSCI 3400. Analytical Methods in Management I
3-0-3. Prerequisite: MATH 1711.
Introduction to linear programming. Emphasis on formulation of problems encountered in professional practice and on interpretation of solutions.

MSCI 3401. Analytical Methods in Management II
3-0-3. Prerequisite: MSCI 3400 or 3200.
Additional applications of linear programming to analysis of management decision problems. Topics include alternatives to the simplex algorithm and special applications.

MSCI 3402. Analytical Methods in Management III
3-0-3. Prerequisite: MSCI 3400 or 3200.
Introduction to the theory and applications of dynamic, integer, and non-linear programming in the formulation of management decision problems.

MSCI 3403. Analytical Methods in Management IV
3-0-3. Prerequisite: MSCI 3100 or 3110.
Analytical and simulation approaches to the analysis of queueing and inventory systems.

MSCI 4801-2-3. Special Topics in Management Science
3-0-3 each. Normally taken by seniors.
Designed to permit students and a professor to pursue a specialized interest in an area of management science not extensively treated in the offerings of the college.

MSCI 4811-2-3-4. Special Topics in Management Science
1-0-1 through 3-0-3. Prerequisite: MATH 1711.
This second course in the methodology and application of management science is programmed with the use of stochastic models in the analysis of managerial and economic decision making.

MSCI 3300. Decision Analysis in Management
3-0-3. Prerequisite: MATH 1711.
An introduction to decision models for management situations under risk and uncertainty including fundamental economic concepts of a theory of rational choice.

MSCI 3400. Analytical Methods in Management I
3-0-3. Prerequisite: MATH 1711.
Introduction to linear programming. Emphasis on formulation of problems encountered in professional practice and on interpretation of solutions.

MSCI 3401. Analytical Methods in Management II
3-0-3. Prerequisite: MSCI 3400 or 3200.
Additional applications of linear programming to analysis of management decision problems. Topics include alternatives to the simplex algorithm and special applications.

MSCI 3402. Analytical Methods in Management III
3-0-3. Prerequisite: MSCI 3400 or 3200.
Introduction to the theory and applications of dynamic, integer, and non-linear programming in the formulation of management decision problems.

MSCI 3403. Analytical Methods in Management IV
3-0-3. Prerequisite: MSCI 3100 or 3110.
Analytical and simulation approaches to the analysis of queueing and inventory systems.

MSCI 4801-2-3. Special Topics in Management Science
3-0-3 each. Normally taken by seniors.
Designed to permit students and a professor to pursue a specialized interest in an area of management science not extensively treated in the offerings of the college.

MSCI 4811-2-3-4. Special Topics in Management Science
1-0-1 through 3-0-3. Prerequisite: MATH 1711.
This second course in the methodology and application of management science is programmed with the use of stochastic models in the analysis of managerial and economic decision making.
MSCI 6020. Quantitative Methods for Management I
3-0-3. Prerequisite: MSCI 6010 or its equivalent.
This first of three core courses focuses on probability
and its uses to structure decision problems.

MSCI 6021. Quantitative Methods for
Management II
3-0-3. Prerequisite: MSCI 6020 or its equivalent.
This second of three core courses includes inferential
statistics and decision analysis. Topics include hypothe-
sis tests, forecasting, regression, Bayesian methods,
utility theory, and simulation.

MSCI 6022. Quantitative Decision Procedures
3-0-3.
This third of three core courses introduces formal
analysis of management and economic decision prob-
lems through the use of optimization methods. Includes
linear programming and mixed integer programming.

MSCI 6023. Cases and Applications in Management
Science
3-0-3. Prerequisites: MSCI 6021, MSCI 6022.
Application of management science in varied func-
tional and organizational contexts. Actual cases are
analyzed, and the results are communicated in oral and
written reports.

MSCI 6051. Computer Simulation of Management
Problems
3-0-3. Prerequisite: MSCI 6021 or equivalent.
Techniques of simulating general management deci-
sions utilizing information from the areas of marketing,
production, finance, and industrial relations.

MSCI 6055. Management Information Systems
2-2-3. Prerequisites: MSCI 6020, MSCI 6021.
Introduction to computer-based information systems
technology and its application to support managerial
decisions.

MSCI 6101. Applications of Statistical Methods to
Management Decision Making
3-0-3. Prerequisite: MSCI 6021 or equivalent.
Theory and applications of elementary multiple
regression analysis in a management framework.

MSCI 6102. Applications of Regression Analysis for
Management
3-0-3. Prerequisite: MSCI 6101.
Multivariate statistical analysis with applications in
business economics.

MSCI 6105. General Decision Theory
3-0-3. Prerequisite: MSCI 6020.
Models of nondeterministic decision situations.
General finite games in extensive and normal forms,
utility indicators, matrix games, mixed extensions, the
fundamental theorem, and computational techniques.

MSCI 6106. Applications of General Decision Theory
in Management and Economics
3-0-3. Prerequisite: MSCI 6020.
Risk games, statistical games, Bayes and min-max
strategies, principle of choice problem, no data and data
variants. Applications in management and economics.

MSCI 6201. Stochastic Optimization
3-0-3. Prerequisite: MATH 4211 or MSCI/MATH 6750.
Optimization of sequential decision models for pro-
duction, congestion, inventory, fisheries, and other
contexts. Myopic policies, Markov decision processes,
and monotone policies.

MSCI 6300. Risk Management
3-0-3. Prerequisites: probability and statistics at the level
of MSCI 6200 and MSCI 6201.
Scope and methods of risk management. Protecting
the firm against losses from pure risks. Loss prevention,
risk retention, and optimal insurance coverage are
considered.

MSCI 6410. Mathematical Programming
3-0-3. Prerequisites: MSCI 6010 and consent of Col-
lege.
Survey of major results in linear programming, goal
programming, and integer programming. Includes cases
which illustrate issues of practical implementation.

MSCI 6411. Seminar in Mathematical Programming
3-0-3. Prerequisite: MSCI 6410.
Student research and/or in-depth study of recent
literature on theory and application of mathematical
programming in management and economics.

MSCI 6750. Stochastic Models in Management
Science
3-0-3. Prerequisites: introductory probability (MATH
4215) and calculus (MATH 2308).
Stochastic process models for managerial contexts
including production, congestion, cash flow, fisheries,
and passenger reservations. Processes include birth and
death, renewal and Markov. Also listed as MATH 6750.

MSCI 8401-2.3-4.5-6. Special Topics
1-0-1 through 6-0-6 respectively. Prerequisite: consent of
College.
Topics of current interest in the field of management
science.

MSCI 8501-2.3-4. Special Problems
Credit to be arranged. Prerequisite: consent of College.
Provides project work experience in the field of
management science.

The College of Sciences and Liberal Studies (COSALS) comprises eight degree-granting
schools—Applied Biology, Chemistry, Geophysical Sciences (graduate degrees only),
Information and Computer Science, Mathematics, Physics, Psychology, and Social
Sciences (one graduate degree only)—and seven non-degree-granting departments—
English, Modern Languages, Music, Physical Education and Recreation, Army ROTC,
Air Force ROTC, and Navy ROTC.
All Tech undergraduates acquire skills and understanding prerequisite to their majors
through COSALS courses in mathematics and the natural sciences. They satisfy
breadth requirements in English, modern languages, psychology, and social sciences.
Students will also find additional opportunities for career and life skills in music,
ROTC, and intramurals.
A detailed description of each degree
program in COSALS is located under the appropriate school heading, as are descriptions
of the courses offered. COSALS courses required or recommended by the
degree-granting programs in engineering, management, and architecture are listed
under the curricula for those degrees.
Another opportunity, especially rich at the
graduate level, is to take advanced courses in interdisciplinary areas and even to undertake
thesis research under the joint direction of faculty members from different departments.
Interdisciplinary programs include biochemistry, biophysics, molecular genetics, micro-
biology, psychobiology, applied statistics, and technology and science policy.
In addition to its degree programs, the
College of Sciences and Liberal Studies
offers students in good standing an opportu-
nity to broaden their areas of expertise or
acquire skills or information beyond their
major degree requirements. With approval of
their major school and in consultation with a
designated adviser or committee in the
school or department offering the certificate
program, students may develop a coherent
plan of study tailored to meet their individual
needs and interests. Students who complete
this special program satisfactorily will re-
cieve a certificate of recognition.

Certificate Programs
College of Sciences and Liberal Studies

School/Department/Programs

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Psychology
Bio-psychology
Engineering
Psychology
Experimental
Psychology
Industrial/Organizational Psychology
Social/Personality Psychology

Social Sciences
History
Philosophy
Political Science
Sociology
International Affairs
Science, Technology, and Society
Urban Studies

**T-4 (Teaching Certificate) Programs**

Biology
Chemistry
Mathematics
Physics

Certificate Programs are available at the bachelor's level.
**Certified at the high school level.

Department of Air Force Aerospace Studies
Established in 1950

Professor and Head—Colonel Winston K. Pendleton; Assistant Professors—Captain John E. Fisher, Captain John A. Hall, Captain Peter P. Penny, Captain Francis J. Spinelli.

General Information
Air Force Reserve Officer Training Corps (AFROTC) program offers two phases. The first two years constitute the General Military Course (G.M.C.) and the last two years, the Professional Officer Course (P.O.C.).

Four-Year Program
Students entering the four-year program enroll in AFROTC courses in the same manner in which they register for other undergraduate courses. A formal application is not required. Students enrolled in the G.M.C. incur no military obligation unless they are on an AFROTC scholarship. Those students desiring to become commissioned officers in the Air Force must compete for entry into the P.O.C., which is normally taken during the last two years of college. Cadets normally attend a four-week field training session conducted at an Air Force base between their sophomore and junior years. Students accepted for the P.O.C. become members of the Air Force Reserve and receive a tax-free subsistence allowance of $100 per month.

Two-Year Program
The two-year program and the last two years of the four-year program are identical in academic content. The basic requirement for entry into this program is that the student must have two academic years remaining in school. This may be at the undergraduate or graduate level, or a combination of the two. Selection of two-year applicants is predicated upon the same criteria as selection of four-year program cadets. In addition, candidates must successfully complete a six-week field training course at an Air Force base during the summer preceding their enrollment and be recommended to enter the P.O.C. upon their return to campus.

AFROTC College Scholarship Program
AFROTC college scholarships are available to qualified cadets in the two- and four-year programs. Scholarships cover tuition, matriculation, health services, student activities fees, and books. All scholarship cadets also receive a tax-free subsistence allowance of $100 per month.

Courses of Instruction

AS 1610. Introduction to Today's Air Force
1-1-1.
United States Air Force doctrine, mission, and organization, with an introduction to strategy.

AS 1620. Air Force Operational Activities
1-1-1.
United States Air Force strategic and general purpose forces, emphasis on their mission, employment, and weapon systems.

AS 1630. Air Force Support Activities
1-1-1.
A survey of support commands and operating agencies of the United States Air Force.

AS 2610. Air Power, the Early Years
1-1-1.
A study of the principles of manned flight and doctrine of air power from the seventeenth century through the 1930s.

AS 2620. Air Power, W.W. II to Korea
1-1-1.
An examination of the development of air power doctrines in W.W.II, the Berlin airlift, and the Korean War.

AS 2630. Air Power, the Later Years
1-1-1.
An examination of the role of air power in contemporary times including the Middle East, Cuba, and Southeast Asia.

AS 3410. Air Force Management I
3-1-3.
Introduction to Air Force management, individual and group behavior, and communicative skills.

AS 3420. Air Force Leadership
3-1-3.
Analysis of leadership dynamics and principles as they apply to command and management.

AS 3430. Air Force Management II
3-1-3.
Fundamentals, functions, and techniques of management. Stresses Air Force approach to management.

AS 4310. Civil-Military Relations
3-1-3.
A study of the environment of current and historical civil military relations and the sociological aspects of the military profession.

AS 4320. U.S. Defense Policy
3-1-3.
An organizational behavior investigation of the formulation and implementation of United States defense policy.

AS 4330. Military Justice
3-1-3.
Functions of the military justice system. Stresses differences and similarities between civil and military law.

School of Applied Biology
Established in 1960


General Information
Programs of study offered by the School of Applied Biology allow students to gain competence in biotechnology, environmental biology, and biophysics. The Institute, with its strength in science and technology, provides unique opportunities for training and research in the biological sciences. The curriculum encourages program enrichment by incorporating course selections from other schools and departments.

The Bachelor of Science degree program consists of a combination of requirements and electives that ensure the attainment of a broad background in biology with sufficient flexibility to satisfy a wide spectrum of individual interests and career objectives. The undergraduate curriculum in biology is well suited to prepare students for employment in industrial, academic, and government laboratories; for graduate study; or for medicine, dentistry, or other health profession schools. The minimum number of total hours required for a bachelor's degree in applied biology is 201.

The School of Applied Biology offers graduate programs that are flexible to serve the specific needs of the student. Also, the School encourages interdisciplinary programs involving other schools within the Institute.

Members of the faculty are actively engaged in research fields such as biophysics,
cell and mammalian physiology, microbiology, microbial genetics, fermentation, cell immobilization, biochemical reactor design and modelling, natural product chemistry, and ecology.

**Curriculum**

**Freshman Year**

<table>
<thead>
<tr>
<th>Course</th>
<th>1st Q.</th>
<th>2nd Q.</th>
<th>3rd Q.</th>
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<tbody>
<tr>
<td>BIOL 1110-1</td>
<td>3-3-4</td>
<td>3-3-4</td>
<td>3-3-4</td>
</tr>
<tr>
<td>General Biology I, II, III</td>
<td>3-3-4</td>
<td>3-3-4</td>
<td>3-3-4</td>
</tr>
<tr>
<td>CHEM 1112-2, 2113</td>
<td>4-3-5</td>
<td>4-3-5</td>
<td>3-3-4</td>
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<tr>
<td>ENGL 1001-2</td>
<td>3-0-3</td>
<td>3-0-3</td>
<td></td>
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<tr>
<td>Analysis of Literature and Language</td>
<td>3-0-3</td>
<td>3-0-3</td>
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<tr>
<td>Elective</td>
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<tr>
<td>English</td>
<td>3-0-3</td>
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<td></td>
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<tr>
<td>MATH 1207-8-9</td>
<td>5-0-5</td>
<td>5-0-5</td>
<td>5-0-5</td>
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<tr>
<td>Calculus I, II</td>
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<tr>
<td>Electives1 Physical Education</td>
<td>X-X-1</td>
<td>X-X-1</td>
<td>X-X-1</td>
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<tr>
<td>Totals</td>
<td>X-X-17</td>
<td>X-X-18</td>
<td>X-X-17</td>
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**Sophomore Year**

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<tr>
<th>Course</th>
<th>1st Q.</th>
<th>2nd Q.</th>
<th>3rd Q.</th>
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<tbody>
<tr>
<td>BIOL 3331</td>
<td>3-0-3</td>
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<tr>
<td>Cell Physiology</td>
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<td></td>
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<tr>
<td>BIOL 3332</td>
<td>4-3-5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biostatistics</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>BIOL 3335</td>
<td>3-0-3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>General Ecology</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electives2 Humanities</td>
<td>3-0-3</td>
<td>3-0-3</td>
<td>3-0-3</td>
</tr>
<tr>
<td>Electives3 Social Science</td>
<td>6-0-6</td>
<td>3-0-3</td>
<td>3-0-3</td>
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<tr>
<td>CHEM 3311-2-3</td>
<td>3-0-3</td>
<td>3-0-3</td>
<td>3-0-3</td>
</tr>
<tr>
<td>Organic Chemistry</td>
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</tbody>
</table>

1. See "Curricula and Courses of Instruction." Department of Physical Education and Recreation, for freshmen physical education requirements for both men and women.
2. See "Humanities and Social Sciences Requirements" for lists of approved courses.
3. Biochemistry may be substituted for CHEM 3313.
4. There are thirty-six hours of electives beyond those required for humanities, social sciences, and P.E. Of these, fifteen hours must be earned in courses chosen from a list of approved courses by the School of Applied Biology; the remaining twenty-one hours are free electives.

**Courses of Instruction**

<table>
<thead>
<tr>
<th>BIOL 1110. General Biology I</th>
<th>3-3-4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction to general biology at the cellular level with an emphasis on cell structure, metabolism, processes, and genetics.</td>
<td></td>
</tr>
<tr>
<td>Text: at the level of Arms and Camp, Biology, 2nd ed.</td>
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<table>
<thead>
<tr>
<th>BIOL 1111. General Biology II</th>
<th>3-3-4</th>
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</thead>
<tbody>
<tr>
<td>Introduction to general biology at the whole organism level with an emphasis on physiological processes and integration of growth and development.</td>
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<tr>
<td>Text: at the level of Arms and Camp, Biology, 2nd ed.</td>
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<table>
<thead>
<tr>
<th>BIOL 1112. General Biology III</th>
<th>3-3-4</th>
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<tbody>
<tr>
<td>Introduction to general biology with an emphasis on evolution, ecology, animal behavior, and the diversity of living organisms.</td>
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</tr>
<tr>
<td>Text: at the level of Clark, Contemporary Biology, 2nd ed.</td>
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<thead>
<tr>
<th>BIOL 3308. Genetic Engineering</th>
<th>3-0-3</th>
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</thead>
<tbody>
<tr>
<td>Introduction to recombinant DNA technology, emphasizing current uses and potential applications of this biotechnology.</td>
<td></td>
</tr>
<tr>
<td>Text: at the level of Freifelder, Reombinant DNA.</td>
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<table>
<thead>
<tr>
<th>BIOL 3310. Introductory Microbiology I</th>
<th>3-0-3</th>
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</thead>
<tbody>
<tr>
<td>Basic biology of bacteria, fungi, algae, protozoa, and viruses, with particular emphasis on bacteriology.</td>
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</tr>
<tr>
<td>Text: at the level of Brock, Biology of Microorganisms.</td>
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<table>
<thead>
<tr>
<th>BIOL 3311. Introductory Microbiology II</th>
<th>3-0-3</th>
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</thead>
<tbody>
<tr>
<td>Biology of bacteria, fungi, algae, protozoa, and viruses, with particular emphasis on bacteriology.</td>
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<table>
<thead>
<tr>
<th>BIOL 3332. Biostatistics</th>
<th>4-3-5</th>
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<tbody>
<tr>
<td>An introduction to statistical methods and their use in the preparation and interpretation of biological experiments.</td>
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<tr>
<td>Text: at the level of Walpole and Myers, Probability and Statistics for Engineers and Scientists.</td>
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</tbody>
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<table>
<thead>
<tr>
<th>BIOL 3334. Genetics</th>
<th>3-3-4</th>
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</thead>
<tbody>
<tr>
<td>Principles of inheritance as described by Mendelian and biochemical genetics.</td>
<td></td>
</tr>
<tr>
<td>Text: at the level of Gardner and Smouat, Principles of Genetics.</td>
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<table>
<thead>
<tr>
<th>BIOL 3335. General Ecology</th>
<th>3-0-3</th>
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</thead>
<tbody>
<tr>
<td>Introduction to the concepts of ecology, designed for biology majors but appropriate for interested nonmajors.</td>
<td></td>
</tr>
<tr>
<td>Text: at the level of Smith, Elements of Ecology and Field Biology, 2nd ed.</td>
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<table>
<thead>
<tr>
<th>BIOL 3337. General Ecology Laboratory</th>
<th>0-6-2</th>
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</thead>
<tbody>
<tr>
<td>Introduction to the analytical techniques and physical and chemical methods useful in modern ecological studies and practical applications of these techniques in field studies in major ecosystems of the southeastern United States.</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>BIOL 3350. Invertebrate Zoology</th>
<th>3-3-4</th>
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</thead>
<tbody>
<tr>
<td>Principles of invertebrate zoology as described by anatomy, functional morphology, and adaptations of invertebrates, emphasizing broad evolutionary patterns.</td>
<td></td>
</tr>
<tr>
<td>Dissection, gross examination, and field observation of major invertebrate phyla.</td>
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</tr>
<tr>
<td>Text: at the level of Barnes, Invertebrate Zoology.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>BIOL 3351. Field Invertebrate Zoology</th>
<th>0-3-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field investigations of the biology of invertebrates, including trips to the Atlantic and Gulf coasts.</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>BIOL 3352. Marine Invertebrate Zoology</th>
<th>3-6-5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic courses in general biology or general zoology or consent of School.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>BIOL 3353. Marine Invertebrate Zoology</th>
<th>3-6-5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morphology, distribution, and systematics of marine invertebrates.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>BIOL 3360. Human Genetics</th>
<th>3-0-3</th>
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</thead>
<tbody>
<tr>
<td>Principles of human genetics.</td>
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</tbody>
</table>
| Text: at the level of the major concepts and problems of human genetics, designed to lead to a better understanding of how the
genetic and environmental components interact to produce the human organism.

Text: at the level of Rothwell, *Human Genetics*.

**BIOL 3370. Evolutionary Biology**
3-0-3 Prerequisite: BIOL 3334 or consent of School.
An introduction to the evolution of living organisms, including the history of evolutionary thought, the history of life from biochemical origin through the paleontological record, with emphasis on genetic mechanisms and the interaction of genotype and environment.

Text: at the level of Futuyma, *Evolutionary Biology*.

**BIOL 3711. Anatomy and Physiology**
3-0-3 Prerequisite: junior standing or consent of School.
Study of human anatomy and fundamental physiological mechanisms. Designed for the advanced student in fields interdisciplinary with the life sciences. Noncredit for biology majors.

Text: at the level of Grollman, *The Human Body*.

**BIOL 3801-2-3-4-5. Special Topics**
1-0-1 to 5-0-5 respectively.
These courses enable the School of Biology to provide offerings dealing with areas of particular current interest in biological science.

**BIOL 4405. General Virology**
3-0-3 Prerequisite: BIOL 3310 or consent of School.
An integrated view of virology, bringing unity to the diversity of bacterial, mammalian, insect, and plant viruses, with special emphasis on biochemical characterization of viruses and their reproduction.

Text: at the level of Luria, Tarnell, Baltimore, and Campbell, *General Virology*, 3rd Ed.

**BIOL 4406. Medical Bacteriology**
3-6-5 Prerequisite: BIOL 3310 or consent of School.
Advanced study of bacteria of significance in human disease and of immunity.

Text: at the level of Burrows, *Textbook of Microbiology*.

**BIOL 4408. Microbial Genetics**
3-6-5 Prerequisite: BIOL 3310 or consent of School.
Microbial genetics, with special emphasis on the integration of genetic studies with biochemical and physical analysis of synthesis, structure, and function of nucleic acids and proteins.

Text: at the level of Stent and Calendar, *Molecular Genetics*, 2nd ed.

**BIOL 4409. Microbial Physiology**
3-6-5 Prerequisite: BIOL 3310, CHEM 3511, or consent of School.
Discussions and laboratory investigations on the physiology of growth and metabolic activities of microorganisms.


**BIOL 4410. Microbial Ecology**
3-0-3 Prerequisite: BIOL 3310 or consent of School.
Advanced discussions on microorganisms occupying key roles in recycling processes, microbial ecosystems, and microbial evolution.


**BIOL 4411. Industrial Microbiology**
3-0-3 Prerequisite: BIOL 3310.
The biochemistry, genetics, and technological applications of microorganisms used in commercial processes.

Text: at the level of Peppier and Perlman, *Microbial Technology*, Vols. I and II.

**BIOL 4413. Air and Water Pollution**
3-0-3.
An introduction to environmental, social, and economic problems resulting from air and water pollution and from current pollution abatement practices. Emphasis on concerns of engineers and biologists in environmental impact studies.

Text: at the level of Hedges, *Environmental Pollution*, 2nd ed., and selected references.

**BIOL 4415. Introductory Radiation Biology**
3-3-4. Prerequisite: consent of School.
A general survey of biological systems and their responses to various kinds of radiations.

Text: at the level of Casaret, *Radiation Biology*.

**BIOL 4416. Industrial Hygiene**
3-0-3.
A survey of chemical, physiological, and biological hazards in the occupational environment to include: adverse effects on the body, methods of evaluation, general control measures, and governmental regulations.

Text: at the level of Ohashi and McElroy, *Fundamentals of Industrial Hygiene*, 2nd ed., and selected references.

**BIOL 4420. Limnology**
3-6-5 Prerequisite: BIOL 3335 or consent of School.
Physics, chemistry, and ecology of fresh water, aquatic communities, and ecosystems. Physical, chemical, and biological investigations of lakes and streams, including several field trips.

Text: at the level of Goldman and Horn, *Limnology*.

**BIOL 4423. Population Biology**
3-0-3. Prerequisite: BIOL 1112 or consent of School.
Population ecology: dynamics and evolutionary mechanisms including modes of selection and environmental modification of genetic systems.

Text: at the level of Wilson and Bossert, *A Primer of Population Biology*.

**BIOL 4437. Fermentation Laboratory**
1-0-4. Prerequisite: BIOL 4409, BIOL 4411.
Laboratory principles of microbial technology with fermentations and modifications of plant and animal products for dairy, beverages, feed, and products of industrial importance.

Text: at the level of Peppier and Perlman, *Microbial Technology*, Vols. I & II.

**BIOL 4440. Plant Physiology**
3-0-3. Prerequisite: BIOL 3331, CHEM 3312.
Chemical transformations in photosynthesis, photophysics, and water relationships, organic nutrition and effects of hormones on growth and development in plants.


**BIOL 4441. Physiology Laboratory**
0-6-2. Prerequisite: BIOL 3331 or CHEM 3312.
The laboratory emphasizes training in the methods used to investigate important physiological principles in plants and animals and the application of these methods in experimental design.

Text: at the level of Schottelius et al., *Physiology Laboratory Manual*.

**BIOL 4446. General Animal Physiology I**
3-0-3. Prerequisite: BIOL 3331, CHEM 3312, or consent of School.
Vertebrate systems physiology including muscles, nerves, circulation, respiration, and body fluid.

Text: at the level of Sellke, *Physiology I*.

**BIOL 4448. General Animal Physiology II**
3-0-3. Prerequisite: BIOL 3331, CHEM 3312, or consent of School.
The physiology of the gastrointestinal, renal, endocrine, and reproductive systems. It is recommended that BIOL 4446 be taken prior to BIOL 4448.

Text: at the level of Sellke, *Physiology II*.

**BIOL 4450. Seminar**
Students and staff presentations of reports on laboratory or literature searches.

**BIOL 4464. Developmental Genetics**
3-0-3. Prerequisite: BIOL 3334 or consent of School.
Transcriptional, translational, and posttranslational control of gene expression in cell differentiation, mechanisms of genomic regulation in eukaryotes, nucleocytoplasmic interactions, genetic aspects of morphogenesis.

**BIOL 4466. Genetics of Populations**
3-0-3. Prerequisite: BIOL 3334 or consent of School.

Text: at the level of Metler and Gregg, *Population Genetics and Evolution*.

**BIOL 4470. Biophysical Genetics**
3-0-3. Prerequisite: BIOL 3334.
Current research on the biophysical mechanisms of replication, transcription, and translation.

**BIOL 4476. Supramolecular Biology**
3-0-3. Prerequisites: BIOL 1111, CHEM 3313, and PHYS 2123, or consent of School.
Structure, formation, and properties of biological objects at a level of organization between single molecules and cells.

**BIOL 4478. Physical Biology**
4-0-4. Prerequisite: PHYS 2123, CHEM 3312, or consent of School.
Use of physics and biochemistry in explaining structure and function of biological systems at atomic and molecular levels. Approach mathematical; quantum mechanics is introduced as needed.

**BIOL 4774. Applications of Microbiology in Sanitary Engineering**
3-3-4. Prerequisite: senior standing, fall quarter.
Microbiology in environmental engineering. Relationships of protozoa, algae, bacteria, and viruses to waterborne disease, the treatment of wastes, and the deterioration of aquatic habitats.

**BIOL 4801-2-3-4-5. Special Topics**
1-0-1 to 5-0-5 respectively.
These courses enable the School of Biology to provide offerings dealing with areas of particular current interest in biological science.

**BIOL 4900-1-2. Special Problems**
Credit hours to be arranged. Prerequisite: BIOL 1111. Special laboratory problems in biology, to be given any quarter with credits (not to exceed six) to be arranged.

**BIOL 6608. Advanced Microbial Genetics**
3-0-3. Prerequisite: BIOL 4408 or 4468 or consent of School.
Genetics of bacteria, plasmids, and viruses. Organization and regulation of expression of genetic material, with special emphasis on new techniques such as genetic engineering.

Text: at the level of Stent and Calendar, *Molecular Genetics*, 2nd Ed.

**BIOL 6609. Advanced Microbial Genetics Laboratory**
0-4-2. Prerequisite: BIOL 4408 or consent of School.
Production, isolation, and characterization of mutants. Testing for mutants.

Text: at the level of Stent and Calendar, *Molecular Genetics*, 2nd Ed.

**BIOL 6611. Advanced Microbial Physiology**
3-0-3. Prerequisite: BIOL 4409 or CHEM 3351 or consent of School.
Advanced studies of selected aspects of the physiology of prokaryotic and eukaryotic microorganisms.

Text: Selected references.

**BIOL 6619. Ecological Systems**
3-0-3. Prerequisite: graduate standing or consent of School.
Fundamentals of ecology with emphasis on the structure and function of ecosystems. Application of ecosystem concepts to environmental impact analysis and environmental management. Designed primarily for planners and engineers; suitable for biologists.

**BIOL 6622. Topics in Ecology**
1-2-2. Prerequisite: BIOL 6619 or consent of School.
Topics of current interest in environmental science such as systems analysis, indicators of pollution, environmental impact evaluation, and environmental monitoring.
BIOL 6624. Systems Ecology 3-0-3. Prerequisite: BIOL 3335 or equivalent.
The use of systems analysis techniques in ecology. Major emphasis on characterization, analysis, and simulation of complex ecosystems. Compartment models, energy circuit models, experimental components models, and feedback dynamics models.

BIOL 6625. Communities and Ecosystems 3-0-3. Prerequisite: BIOL 3335 or consent of School.
Theoretical and practical aspects of the description, analysis, classification, and current understanding of the functional processes in major communities and ecosystems of North America.

Text: literature, references, and review articles.

BIOL 6635. Air Pollution Biology 3-3-4. Prerequisites: BIOL 3335 and either BIOL 4440, 4446, or 4448, or consent of School.
Environmental factors as well as organismal physiological responses to light, temperature, water, and mineral nutrients will be emphasized.

Text: literature, references, and review articles.

BIOL 6644. Photobiology 3-3-4. Prerequisite: graduate standing or consent of School.
The interactions of light with biomolecules and the roles of light in the environment, in biology and medicine will be considered. Processes of vision, photomorphosis, photosynthesis, and photoperiodism will be included.


BIOL 6646. Mammalian Physiology 3-3-4. Prerequisites: BIOL 4446, 4448, or equivalent or consent of instructor.
Physical, biochemical, and biological phenomena underlyng organ functions. Integration of physiological processes and basic techniques of physiological analysis.

BIOL 6649. Neurobiology 3-0-3. Prerequisites: CHEM 3313, PHYS 2123, BIOL 1111, or consent of School.
A survey of some of the basic mechanisms of neural function and methods used to study them, with particular reference to the visual system.

Text: at the level of Kuffler, Nicholls, and Martin, From Neuron to Brain, 2nd ed.

BIOL 6650. Invertebrate Behavior 3-0-3. Prerequisite: consent of School.
A review of the literature on the behavior of invertebrates. Emphasis will be placed on the mechanisms of orientation of bacteria, protozoa, nematodes, and insects.

Text: none; readings will be taken from the primary research literature and recent review articles.

BIOL 6664. Selected Topics in Regulatory Biology 3-0-3. Prerequisite: BIOL 3334, CHEM 3511, or consent of School.
"Second messengers," cyclic AMP, prostaglandin interactions, positive and negative transcriptional control in prokaryotes, cyclic AMP and catabolite repression, transcriptional regulation in eukaryotes.

BIOL 6676. Advances in Supramolecular Biology 3-0-3. Prerequisites: BIOL 1111, CHEM 3511 or PHYS 4251, and PHYS 2123 or consent of School.
Advanced treatment of the organization and assembly of biological structure at a level of complexity between single molecules and cells (membranes, viruses, ribosomes).

Text: selected references.

BIOL 6730. Biological Effect of Radiations 3-3-4. Prerequisite: consent of School.
An introduction to the effects of nuclear radiation upon biological systems for graduate students in the nuclear science and engineering curriculum.

BIOL 7000. Master's Thesis

BIOL 8001. Seminar 2-0-2. Prerequisite: graduate standing.
Discussion group composed of staff and graduate students.

BIOL 8013-4-5. Seminar in Microbiology 2-0-2 each. Prerequisite: graduate standing.
Recent advances in microbial physiology and metabolism, industrial and applied microbiology, microbial ecology, medical microbiology, and immunology.

BIOL 8023-4-5. Seminar in Ecology 2-0-2 each. Prerequisite: graduate standing.
Topics of current interest and recent advances in the general areas of population growth and limitation, interspecific relationships, and the structure, productivity, and stability of ecosystems.

BIOL 8043-4-5. Seminar in Physiology 2-0-2 each. Prerequisite: graduate standing.
Current concepts of membrane structure, molecular and ionic transport mechanisms, endocrinology, cardiac, nervous, and muscular function, physiology of development, student and faculty presentations.

BIOL 8063-4-5. Seminar in Genetics 2-0-2 each. Prerequisite: graduate standing.
Topics of current interest in the areas of cyogenetics, developmental genetics, molecular genetics, maturation, and the genetics of man and populations. Student and faculty presentations.

BIOL 8101-2-3-4-5. Special Topics

Chemistry

School of Chemistry

Established in 1906

Director and Professor – Robert A. Pierotti
Coordinator of Graduate Programs and Professor – Raymond F. Borkman
Coordinator of Undergraduate Programs and Associate Professor – Harold R. Hunt

General Information

Included in the school are courses in chemistry required for various engineering and science curricula; for students interested in medical school; for the degree Bachelor of Science in Chemistry; and for graduate work leading to the degrees Master of Science in Chemistry and Doctor of Philosophy in Chemistry.

Undergraduate Program

Students receive the degree Bachelor of Science in Chemistry upon the completion of the following prescribed curriculum of which seventy-three quarter hours are elective work. The significant number of free elective hours in the chemistry curriculum permits one to take necessary concentrated elective work to achieve certificate programs in written and oral communications, foreign languages, social sciences, and other available programs of the Institute. In addition, interdisciplinary minor options in geochimistry and T-4 certification (in association with Georgia State University) are also possible. The judicious use of these free electives also enables the student to achieve considerable knowledge of other disciplines at Georgia Tech such as chemical engineering, physics, mathematics, management, textiles, ceramics, and biology. Too, these electives enable those who are interested in medical and dental schools to meet admission requirements of these schools.

Additional information regarding undergraduate programs is available by writing to the Undergraduate Coordinator, School of Chemistry, Georgia Institute of Technology, Atlanta, Georgia 30332.

Curriculum

Freshman Year

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<thead>
<tr>
<th>Course</th>
<th>1st Q.</th>
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<tr>
<td>CHEM 1111-2</td>
<td>4-3-5</td>
<td>4-3-5</td>
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<tr>
<td>CHEM 2114</td>
<td>Chemical Principles</td>
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<td>3-0-3</td>
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<tr>
<td>CHEM 2115</td>
<td>Quantitative Measurements</td>
<td>1-6-3</td>
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<tr>
<td>MATH 1307-8-9</td>
<td>Calculus I, II, III</td>
<td>5-0-5</td>
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<tr>
<td>ENGL 1001-2</td>
<td>Analysis of Literature and Language</td>
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<td>Electives*</td>
<td>Foreign Language</td>
<td>3-0-3</td>
<td>3-0-3</td>
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<td>17-7-19</td>
<td>16-8-18</td>
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Sophomore Year

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<tr>
<td>CHEM 3311-2-3</td>
<td>Organic Chemistry</td>
<td>3-0-3</td>
<td>3-0-3</td>
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<tr>
<td>CHEM 3381-2</td>
<td>Organic Chemistry Laboratory</td>
<td>0-6-2</td>
<td>0-6-2</td>
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<tr>
<td>MATH 2307-8</td>
<td>Calculus IV, V</td>
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<tr>
<td>PHYS 2121-2-3</td>
<td>Physics</td>
<td>4-3-5</td>
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Curricula and Courses of Instruction
Junior Year

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<td>Organic Chemistry</td>
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<td>CHEM 3411-2</td>
<td>Physical Chemistry</td>
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<td>CHEM 3481-2</td>
<td>Physical Chemistry</td>
<td>0-6-2</td>
<td>0-6-2</td>
</tr>
<tr>
<td>CHEM 3121-2</td>
<td>Inorganic Chemistry</td>
<td>3-0-3</td>
<td>3-0-3</td>
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<td>CHEM 4211-2</td>
<td>Instrumental Analysis I, II</td>
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Elective

| 3-0-3 |

Free

| 3-0-3 | 3-0-3 | 3-0-3 |

Totals

| 15-3-16 | 15-9-18 | 13-9-16 |

Senior Year

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<td>Electives</td>
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<tr>
<td>Electives</td>
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<td>X-X-6</td>
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Totals

| 12-12-16 | 12-12-16 | X-X-16 |

Graduate Programs

The School of Chemistry also offers programs for both the master's and doctoral degrees in the fields of analytical, biochemistry, inorganic, nuclear, organic, and physical chemistry.

The requirements for the master's degree consist of an accepted program of thirty-three quarter hours of course work plus an original research thesis on the master's level. The student and his or her advisory committee design the program, which may be largely or totally in chemistry, to suit the needs and objectives of the individual. The goal of the doctoral program is greater proficiency and depth in the chemical area with particular emphasis being placed on original, independent, and scholarly research. The only course work demanded is the Institute requirement of a minimum of earned credit hours in a minor field, which may be any field of study chosen by the student in consultation with his or her adviser. The area need not necessarily be beyond the broad area of chemistry. Most students, however, do take a number of courses during their studies beyond the minor requirements. The numbers of such other courses vary with individuals, the major field interests, and previous background, as well as long-range goals. Active research fields include:

1. Physical chemistry—quantum theory, spectroscopy, light scattering, Raman and fluorescence spectroscopy, mass spectrometry, atomic ionization, and radioactive isotopes.
2. Organic chemistry—synthesis and properties of organic molecules, coordination compounds, kinetics and mechanisms of reactions, metal hydrides, models for biologically active metal-containing compounds, X-ray diffraction, ESR spectroscopy, and magnetic susceptibility. Organic chemistry—multistep synthesis, physical organic chemistry, heterocyclic chemistry, natural products, organometallic chemistry, crown ethers, electrochemistry, theoretical organic chemistry, carboxylics, and phase transition catalysis.
3. Physical chemistry—molecular and ion beam kinetics, ab initio calculations, electronic spectroscopy, light scattering, Raman spectroscopy, surface phenomena, protein dynamics and photochemistry, bonding theory, EXAFS, NMR spectroscopy, and porphyrin properties. Analytical chemistry—electrochemistry, mass spectrometry, atomic absorption, RF plasmas, and porphyrin chemistry. Nuclear chemistry—X-ray fluorescence, radiopharmaceuticals, inner shell ionization, and radioactive isotopes.

Additional information regarding graduate work is available by writing to the Graduate Coordinator, School of Chemistry, Georgia Institute of Technology, Atlanta, Georgia 30332.
CHEM 2115. Quantitative Measurements
1-6-3. Prerequisite: concurrent with or following CHEM 2114; or CHEM 2113.
Experimentation concerned with synthesis, analysis, and data interpretation. For chemistry majors.

CHEM 2901-2-3. Special Problems—Chemistry
Credit hours to be arranged. Prerequisite: CHEM 1112 and consent of School.
Individualized instruction which will include library, conference, and laboratory experiences.

CHEM 3121-2. Advanced Inorganic Chemistry I, II
3-0-3. Prerequisite: CHEM 3411.
A study of the reactions and structures of inorganic compounds and the principles, generalizations, and theories which assist in understanding their behavior.

3-0-3 each. Prerequisite: CHEM 2113, 2114, or consent of School.
Principal classes of organic compounds, aliphatic and aromatic.

CHEM 3381-2. Organic Chemistry Laboratory I, II
0-6-2 each. Concurrent with or following CHEM 3311-2 respectively; CHEM 3381 prerequisite to CHEM 3382.
Studies of reactions, preparation and the techniques used in the organic laboratory.

CHEM 3383. Organic Chemistry Laboratory
0-6-2. Prerequisite: CHEM 3382. Prerequisite or corequisite: CHEM 3313.
Studies of reactions, preparations, and the techniques used in the organic laboratory.

CHEM 3386. Organic Chemistry Laboratory
1-12-5. Prerequisite: CHEM 3382. Prerequisite or corequisite: CHEM 3313.
Advanced study of organic reactions, preparations, separations, instrumentation, and techniques.

CHEM 3411. Physical Chemistry I
3-0-3. Prerequisite: CHEM 2113 or 2114, PHYS 2122, MATH 2307.
Quantum mechanics and atomic structure, bonding theory, molecular spectroscopy.
Text: at the level of Moore, Physical Chemistry.

CHEM 3412. Physical Chemistry II
3-0-3. Prerequisite: CHEM 2113 or 2114, PHYS 2122, MATH 2307.
Chemical thermodynamics, energetics of chemical reactions, and changes of state.
Text: at the level of Moore, Physical Chemistry.

CHEM 3413. Physical Chemistry III
3-0-3. Prerequisite: CHEM 3412.
Electrochemistry, rates of chemical reactions, kinetic theory of gases, statistical mechanics.
Text: at the level of Moore, Physical Chemistry.

CHEM 3481. Physical Chemistry Laboratory I
0-6-2. Prerequisite: concurrent with or following CHEM 3412.
Applications of physical chemistry principles.

CHEM 3482. Physical Chemistry Laboratory II
0-6-2. Prerequisite: CHEM 3481, concurrent with or following CHEM 3413.
Applications of physical chemistry principles.

CHEM 3492. Physical Chemistry Laboratory III
1-6-3. Prerequisite: CHEM 3482 and concurrent with or following CHEM 4401 or consent of School.
Theory of molecular spectroscopy, electron diffraction, X-ray diffraction, neutron diffraction, and magnetic methods applied to the determination of molecular structure.

CHEM 4452. Chemistry of the Solid State
3-0-3. Prerequisite: CHEM 4311 or consent of School.
Applications of the concepts of physical chemistry to the structure of solids and their chemical and physical properties.
Text: at the level of Barrow, Physical Chemistry.

3-0-3. Prerequisite: CHEM 3312 or consent of School.
The chemistry and biochemistry of proteins, lipids, carbohydrates, nucleic acids, and other biomolecules.
Text: at the level of Lehninger, Biochemistry.

CHEM 4582. Biochemistry Laboratory
1-6-3. Prerequisite: CHEM 3511 or consent of School.
Laboratory techniques in the isolation and characterization of proteins and nucleic acids with special emphasis on modern practices in biochemistry.

CHEM 4701. Chemistry of Nuclear Technology
3-3-4. For students in nuclear engineering.
Principles of interaction, radiation, and radiochemical separation methods for actinide elements and fission products, and topics related to production and utilization of nuclear energy.

CHEM 4801-2-3. Special Topics—Chemistry
1-0 through 3-0-3 respectively. Prerequisite: junior standing or consent of School.
Lecture courses in special topics of current interest in chemistry. Topics will vary from year to year.

CHEM 4901-2-3. Special Problems
Credit to be arranged. Prerequisite: consent of School.
Individualized instruction which will include library, conference, and laboratory work.

CHEM 6111-2. Advanced Inorganic Chemistry I, II
3-0-3 each. Prerequisite: consent of School.
The theory of bonding and structure of inorganic compounds and the chemistry of the elements.

CHEM 6141. Chemical Applications of Group Theory
3-0-3. Prerequisite: CHEM 3112 or consent of School.
An introduction to basic definitions and theorems of group theory and their application to molecular symmetry and quantum mechanics and use in valence bond, molecular orbital, and ligand field treatments.

CHEM 6150. Organometallic Chemistry
3-3-4. Prerequisite: consent of School.
Survey of organometallic chemistry of main group elements, particularly lithium, sodium, beryllium, magnesium, zinc, cadmium, mercury, boron, and aluminum, emphasizing structure, bonding, reaction mechanisms, and applications.

3-0-3 each. Prerequisite: consent of School.
A discussion of molecular structure based upon quantum mechanical principles.
CHEM 6421-2. Chemical Thermodynamics I, II
3-0-3 each. Prerequisite: CHEM 3411-2-3.
Laws of thermodynamics and their chemical applications. Introduction to chemical kinetics and statistical mechanics.

CHEM 6451. Surface Equilibria
3-0-3. Prerequisite: consent of School.
Classical and statistical thermodynamics of surface systems, intermolecular forces at the gas-solid interface, adsorption phenomena, and capillarity.

CHEM 6511-2. Advanced Enzymology I, II
3-0-3 each. Prerequisite: CHEM 4512 or consent of School.
Structure and chemistry of proteins, enzyme structure and mechanism, enzyme kinetics, enzyme inhibitors, and medicinal chemistry.

CHEM 6541. Advanced Physical Chemistry
3-0-3. Prerequisites: CHEM 3411 and 3412, or consent of instructor.
Applications of the principles and techniques of physical chemistry in biochemistry with emphasis on the equilibrium and dynamic behavior of macromolecules in solution.

CHEM 6610. Nuclear Chemistry
3-0-3. Prerequisites: CHEM 3413 and MATH 2308.
Properties and structure of the atomic nucleus, radioactivity and decay schemes, interaction of radiation with matter, detection and experimental methods, nuclear reactors, radiochemical techniques. Text: at the level of Evans, The Atomic Nucleus.

CHEM 6612. Nuclear Chemistry
3-0-3. Prerequisite: CHEM 6610.
A continuation of CHEM 6610.

CHEM 6621. Fast-Neutron Interactions
3-0-3. Prerequisite: CHEM 6622 or consent of School.

CHEM 6622. Nuclear Fission
3-0-3. Prerequisite: CHEM 6612 or consent of School.
The study of statistical mechanical ensembles, partition functions and their relationship to thermodynamics, lattice statistics, molecular distribution and correlation functions, the theories of liquids and solutions, phase transitions, and cluster theory.

CHEM 7431-2. Principles of Quantum Mechanics I, II
3-0-3. Prerequisite: CHEM 6411 or PHYS 4143.
Important concepts of quantum chemistry at the intermediate level including: angular momentum, perturbation theory, electronic structure of molecules, and radiation matter interaction. Applications will vary from year to year.

CHEM 7451. Chemical Kinetics
3-0-3. Prerequisites: CHEM 6422-1-2.
Mechanisms of chemical reactions, cross sections, and rate constants. Elastic, inelastic, and rearrangement channels are discussed using quantum and semiclassical techniques.

CHEM 8111-2. Special Topics in Inorganic Chemistry
3-0-3 each. Prerequisite: CHEM 3112.
Topics to be discussed vary from year to year, will include mechanisms of inorganic reactions, Ligand Field theory, and bonding in inorganic compounds.

CHEM 8211. Special Topics in Analytical Chemistry
2-3-3. Prerequisite: consent of School.
Discussions of specialized areas of analysis: spectrophotometry, polarography, coulometry, chromatography, and others. Content of course varies from year to year.

CHEM 8311-2. Special Topics in Organic Chemistry
3-0-3 each. Prerequisite: consent of School.
Topics vary from year to year, will include such subjects as catalysis and synthetic methods and their applications to research in organic chemistry.

CHEM 8351-2. Special Topics in Physical Chemistry
3-0-3 each. Prerequisite: CHEM 3413 or consent of School.
Topics vary from year to year, will include such subjects as photochemistry, solid state, surface chemistry, and radiation chemistry.

CHEM 8461. Special Topics in Nuclear Chemistry
3-0-3. Prerequisite: CHEM 6612 or consent of School.
Topics vary from year to year, will include nuclear fission, radiochemical techniques, nuclear reactions, and radiation chemistry.

CHEM 8481-2. Special Problems—Chemistry
Credit to be arranged. Prerequisite: consent of School.
A laboratory course dealing with special problems of current interest in chemistry.

CHEM 9000. Doctoral Thesis

Department of English


Traditions: The Department offers instruction in American Literature, Drama and Film, Literature and Science, and the Western Tradition in Literature and Art. All courses in these programs carry humanities credit. Certificates are available in American Literature and Drama and Film.

American Literature contains two tracks, "American Approaches to Poetry, Fiction, and Drama" and "The Southern Literary Tradition." Both groups of courses investigate how American cultural events, historical movements, and philosophies influenced and were influenced by the national literature. Students may also create an individual track with the help of an adviser from the program. Drama and Film offers courses on specific periods, authors, social issues, and techniques in the history of these two related media.

The Western Tradition in Literature and Art offers interdisciplinary courses in western world literature. These courses include historical surveys, thematic surveys, and in-depth studies of specific literary and cultural traditions.
Technical and Business Communication Certificate Program

These courses teach the principles of effective communication and give practice in applying them in the practical form of briefings, speeches, memoranda, technical reports, and other standard forms of business communication. (None of the courses in this program carries humanities credit.)

Advanced Placement

Students with a score of 4 or 5 on the College Entrance Examination Board Advanced Placement Examination in “Composition and Literature” or “Language and Composition” receive credit for ENGL 1001-2. Students with College Board SAT Verbal scores of 650 (or 600 with English Achievement scores of 600) may take the Department advanced placement exam during FASET. Those who pass the Department exam and then earn an “A” or “B” in a Department literature course will receive credit for ENGL 1001-2 as well as the course taken.

Regents' Examination

This exam measures proficiency in reading and English composition. A passing score is required by the Board of Regents for graduation. The exam is designed, administered, and graded by the Regents' staff. Students who have not passed the exam by the time they have completed fifty hours of degree credit must schedule ENGL 0020 in their following quarter in residence. In addition to ENGL 0020, the Department offers short workshops in preparation for the exam, consultation with those who have failed, and an appeal system for those who fail.

Courses of Instruction

ENGL 0010. Remedial English 2-3-3. (Pass/fail basis only.)

Special attention given to developing the vocabulary and basic skills in reading and writing for students who need additional preparation for college-level English. Lectures, exercises, laboratory. Cannot be counted for credit toward graduation.

ENGL 0020. Writing the Impromptu Essay 3-0-3. (Pass/fail basis only.)

Special attention given to developing basic skills in writing for students who need additional preparation for college-level English. Lectures, exercises. Cannot be counted for credit toward graduation.

ENGL 1001-2. Analysis of Literature and Language I, II 3-0-3 each. Freshman year. Courses must be taken in numerical sequence and are prerequisite to all other English courses.

A study of literary and expository texts to determine rhetorical strategies. Intensive writing practice in these strategies, with emphasis on organizing ideas, evidence, and readership in paragraph sequences and then on forecasting and monitoring paragraph sequences.


A study of English literature since Shakespeare, with emphasis on significant figures and their works. Lectures, reports, papers, quizzes.

ENGL 2037-8-9. Acting and Producing the Play I, II, III 0-3-1 each.

Participation in the DramaTech production of plays through a variety of activities, including not only acting but also crew work: set design and building, publicity, accounting and sales, box office, lights, sound, make-up and costumes, special effects, stage managing.

ENGL 2041-2-3. Literature for International Students 3-0-3 each. Sophomore year. Prerequisites: FL 1031-2-3.

An introduction to American literature, with continued training in writing and speaking American English.

ENGL 2101. Introduction to Drama and Film 3-0-3. Prerequisites: ENGL 1001-2.


ENGL 2301. Introduction to Literature and Science 3-0-3. Prerequisites: ENGL 1001-2, 2101.

Focuses on the technical report. Includes preliminary instruction in letter and memorandum writing.

ENGL 2401. Introduction to the Western Tradition 3-0-3. Prerequisites: ENGL 1001-2, 2101.

Introduction to the poetry of Chaucer in Middle English and to the origins of the modern English language. Lectures, exercises, laboratory. Cannot be counted for credit toward graduation.

ENGL 2501. Technical Writing 3-0-3. Prerequisites: ENGL 1001-2.

Instruction in the basic principles of effective public speaking, with emphasis on practice and criticism. The course is conducted as a laboratory.


Introduction to major issues in technical communication, including readability theory, audience analysis, documentation techniques, and the principles of document design through examples of professional writing. Taught as lecture/workshop.


Instruction in the basic principles of effective public speaking, with emphasis on practice and criticism. The course is conducted as a laboratory.

ENGL 3020. Technical Writing 3-0-3. Prerequisites: ENGL 1001-2. Does not carry humanities credit. Junior or senior year.

Focuses on the technical report. Includes preliminary instruction in letter and memorandum writing.

ENGL 3037-8-9. Acting and Producing the Play I, II, III 0-3-1 each. Prerequisites: ENGL 2037-8-9.

See ENGL 2037-8-9.

ENGL 3041. Writers in the Age of Galileo 3-0-3. Prerequisites: ENGL 1001-2.

Study of works of three of the following: Donne, Bacon, Jonson, Milton, Defoe. Emphasis on their reflection of social, scientific, philosophical attitudes of the age.

ENGL 3042. Writers in the Age of Newton 3-0-3. Prerequisites: ENGL 1001-2.

Study of works of three of the following: Swift, Fielding, Sterne, Wordsworth, Keats. Emphasis on their reflection of social, scientific, philosophical attitudes of the age.

ENGL 3043. Writers in the Age of Darwin 3-0-3. Prerequisites: ENGL 1001-2.

Study of works of three of the following: Swift, Fielding, Sterne, Wordsworth, Keats. Emphasis on their reflection of social, scientific, philosophical attitudes of the age.

ENGL 3044. Writers in the Age of Freud and Einstein 3-0-3. Prerequisites: ENGL 1001-2.

Study of works of three of the following: James, Yeats, Shaw, Lawrence, Eliot. Emphasis on their reflection of social, scientific, philosophical attitudes of the age.

ENGL 3051. Chaucer I 3-0-3. Prerequisites: ENGL 1001-2.

Introduction to the poetry of Chaucer in Middle English. Major emphasis on the study of The Canterbury Tales.


A study of the works of James Joyce. With particular emphasis on Joycean techniques of fiction as developed in Ulysses and other selected works.

ENGL 3058. Contemporary Drama 3-0-3. Prerequisites: ENGL 1001-2.

An analytic survey of prominent playwrights and trends in contemporary drama. Lectures, reports, collateral reading, quizzes.

ENGL 3059. Contemporary Fiction 3-0-3. Prerequisites: ENGL 1001-2.

An analytic study of prominent writers and trends in contemporary fiction. Lectures, reports, collateral reading, quizzes.

ENGL 3072. The Civil War in Literature 3-0-3. Prerequisites: ENGL 1001-2, 2201.

A study of selected works of literature dealing with the American Civil War, with emphasis on the relation of history and literature.

ENGL 3076. Faulkner 3-0-3. Prerequisites: ENGL 1001-2, 2201.

A study of selected works of William Faulkner with particular emphasis on major themes and the nature of his narrative art.

ENGL 3081. Shakespeare in Historical Context 3-0-3. Prerequisites: ENGL 1001-2, 2101.

Greek drama in context of mythic sources. The shift from epic to tragic world view and the separation of comic from heroic through study of Homer, Aeschylus, Sophocles, Euripides, Aristophanes.

ENGL 3131. The Narrative Art of the Film 3-0-3. Prerequisites: ENGL 1001-2, 2101.

Introduction to major forms of film narrative and to principles used in analyzing and understanding cinematic storytelling.

ENGL 3151. Shakespeare: Comedy and History 3-0-3. Prerequisites: ENGL 1001-2, 2101.

Focuses on Shakespeare's methods and on the concern comedy and history plays have for society as a whole. Major works of Shakespeare's contemporaries are studied as appropriate.

ENGL 3152. Shakespeare: Tragedy and Romance 3-0-3. Prerequisites: ENGL 1001-2, 2101.

Focuses on Shakespeare's methods and on the theme of the suffering individual, sacrificed and triumphant. Major works of Shakespeare's contemporaries are studied as appropriate.

ENGL 3161. Science Fiction 3-0-3. Prerequisites: ENGL 1001-2.

Study of selected works of science fiction, with special emphasis on the relationship of their ideas to those of mainstream fiction, science, politics, and history. Seminars, reports, papers.
ENGL 3841. Social Issues in Drama
3-0-3. Prerequisites: ENGL 1001-2, 2101.
Brings a concern with theme or issue to bear on
a collection of plays chosen for their social context as well as
their aesthetic achievement.

ENGL 3201. American Fiction
3-0-3. Prerequisites: ENGL 1001-2, 2201.
Focuses on novels that reflect American reactions to
materialism and idealism, to individual freedom and
social responsibility, and to the continuing struggle for
the American Dream.

ENGL 3203. American Drama
3-0-3. Prerequisites: ENGL 1001-2, 2201.
Treats a wide range of typically American themes and
motifs in the work of America's major dramatists.
Themes range from the moral consequences of Puritan
repression to the conflict between materialism and
idealism.

ENGL 3205. American Poetry
3-0-3. Prerequisites: ENGL 1001-2, 2201.
Treats such themes as the Puritan outlook, American
optimism, and the American response to nature as these
themes are presented by 19th- and 20th-century poets.

ENGL 3211. Major Figures in Nineteenth-Century
American Literature
3-0-3. Prerequisites: ENGL 1001-2, 2201.
Concentrates on the works of Poe, Emerson,
Hawthorne, Melville, and other writers in the American
Renaissance.

ENGL 3225. The Southern Renaissance
3-0-3. Prerequisites: ENGL 1001-2, 2201.
Investigates this major 20th-century literary movement
which treated the history of the South in poetry, essays,
and novels.

ENGL 3227. Contemporary Southern Literature
3-0-3. Prerequisites: ENGL 1001-2, 2201.
Examines the ways such contemporary Southern
writers as Eudora Welty and Alice Walker view the
South, its people, changing values, and social issues.

ENGL 3251. Hemingway and His Contemporaries
3-0-3. Prerequisites: ENGL 1001-2, 2201.
Examines the works of Ernest Hemingway and other
major writers of the 1920s as they dramatize the shattering
effect of World War I and offer perspectives on the
modern world which emerge in the post-war years.

ENGL 3401-2. The Western Traditions 1, II
3-0-3. Prerequisite: ENGL 1001-2.
Great works of ancient and modern literature repre-
senting the dominant traditions of Western civilization,
the classical and the Judeo-Christian. Courses need not
be taken in sequence.

ENGL 3411-2. Arts and Ideas 1, II
3-0-3. Prerequisite: ENGL 1001-2.
Major ideas of Western culture expressed in literature
and other art forms—painting, sculpture, architecture,
and music. Courses need not be taken in sequence.

ENGL 3461. The Old Testament in the Western
Tradition
3-0-3. Prerequisites: ENGL 1001-2.
Examines selected Old Testament literature with
special emphasis on man's continuing efforts to define
deity, society, and self.

ENGL 3462. The New Testament in the Western
Tradition
3-0-3. Prerequisites: ENGL 1001-2.
Examines selected New Testament literature with
special emphasis on man's continuing efforts to define
deity, society, and self.

ENGL 3483. The Concept of Humanism
3-0-3. Prerequisites: ENGL 1001-2.
Examines the celebration of the place of the individual
in the cosmic order in representative literary and visual
artists from the Renaissance to the twentieth century.

ENGL 3501. Poetry Writing
3-0-3. Prerequisites: ENGL 1001-2.
Intensive work in the composition of poetry. Con-
ducted as a seminar/tutorial.

ENGL 3502. Fiction Writing
3-0-3. Prerequisites: ENGL 1001-2.
Intensive work in composition of fiction. Conducted
as a seminar/tutorial.

ENGL 3786. The Immigrant Experience
3-0-3. Prerequisites: ENGL 1001-2, HIST 1001 or
1002.
The history and literature of immigrant/ethnic groups
such as English, Blacks, Irish, Germans, Asians, South-
ern and Eastern Europeans, Hispanics; exploring Old
World reasons for emigrating. New World reactions
assimilation, bigotry, restrictive immigration policies,
the Second World War relocation camp experience,
alienation, the American Dream fulfilled. Lectures and
papers. Jointly taught by the Department of English and
School of Social Sciences.

ENGL 4020. Advanced Technical Writing
3-0-3. Prerequisites: ENGL 1001-2, 3020.
Study of intensive writing and editing projects for
graduate students who need to communicate technical
information effectively.

ENGL 4082. Man and Society
3-0-3. Prerequisites: ENGL 1001-2.
Intensive study of works of modern literature which
treat the theme of man and himself.

ENGL 4083. Current Issues
3-0-3. Prerequisites: ENGL 1001-2.
Intensive study of works of modern literature which
treat selected issues of concern.

ENGL 4132. Studies in Film
3-0-3. Prerequisites: ENGL 1001-2, 2101.
Examines in depth a theoretical issue in film criticism.

ENGL 4575. Sex Roles: Their Development and
Influence
3-0-3. Prerequisites: ENGL 1001-2.
Psychological principles, legal facts, and literary
explorations are integrated in an examination of the roles
of men and women from three time perspectives: histori-
cal, current, and future. Readings, lectures, discussions,
and invited panelists will be utilized. Jointly taught by
English, Psychology, and Social Sciences.

ENGL 4801-11. Special Topics
1-0-1. Prerequisites: consent of the Department.
Study of special topics of current interest in the humanities.

ENGL 4803-13. Special Topics
3-0-3. Prerequisites: ENGL 1001-2.
Study of special topics of current interest as reflected
in selected literary works.

ENGL 4833. Special Topics in American Literature
3-0-3. Prerequisites: ENGL 1001-2, 2201.
Study of special topics of current interest.

ENGL 4843. Special Topics in Southern Literature
3-0-3. Prerequisites: ENGL 1001-2, 2201.
Study of special topics of current interest.

ENGL 4901-2-3-4. Special Problems
Credit to be arranged. Prerequisites the consent of the
Department. Does not carry humanities credit.
Study of specialized aspects of literature and language
selected on basis of current interest.

ENGL 6023. Seminar in Technical Communication
3-0-3. Prerequisite: graduate standing or consent of
the Department.
Series of intensive writing and editing projects for
graduate students who need to communicate technical
information effectively.

School of Geophysical Sciences
Established in 1970

Director and Professor—C. S. Kiang;
Professors—George Chimonas, Douglas D.
Davis, Franco Einaudi, Gerald W. Grams,
C. G. Justus, L. Timothy Long, R. G.
Roper, Charles E. Weaver, H. L. Windom;
Associate Professors—Kevin C. Beck,
William L. Chamicles, Robert P. Lowell,
E. Michael Perdue, Charles O. Pollard, Jr.,
J. Helmut Reuter, J. M. Wampler; Assistant
Professors—R. E. Habermann, Jean-Claude
Mareschal; Principal Research Scientists—
Fred N. Alyea, Derek M. Cummond; Senior
Research Scientists—John Hall, Edward M.
Patterson; Research Scientist II—John O.
Bradshaw, Carlos Cardelino, Alessandro
Coletti, Lonzy Lewis, Michael O. Rodgers,
Luther Roland; Adjuncts: Professors—Julius
Chang, Paul Crutzen, Donald Lenschow,
Douglas K. Lilly, David W. Menzel,
Wolfgang Seiler; Associate Professors—
Jackson O. Blanton, Demetrious Lallas, G.
Lafayette Maynard, Ronald G. Prinn,
Gordon Wallace; Assistant Professors—James
L. Harding, Barry Hucbert.

General Information
The School of Geophysical Sciences offers
graduate study programs for those interested
in understanding the earth and man's physical
environment. The programs lead to the degrees of Master of Science and Doctor of
Philosophy. The term geophysical sciences,
in the broadest sense, includes both physical
and chemical studies of the earth, its waters,
and its atmosphere. These studies provide
basic information for assessing the earth's
resources and the evolution of the environment.

Persons with a bachelor's degree in geol-
ogy, meteorology, atmospheric science,
chemistry, physics, mathematics, biology, or
engineering may enter the graduate program.
The program of study for each student will
be tailored to accommodate his or her back-
ground and interests.
Present areas of specialization include geophysics, geochemistry, mineralogy, sedimentology, environmental geology, atmospheric dynamics, atmospheric physics, atmospheric chemistry, and physical meteorology. Students carry out interdisciplinary studies in such areas as crystallography (crystal physics), hydrogeology, engineering geology, nuclear geochemistry, organic geochemistry, environmental studies, and energy-meteorology relationships.

The School conducts research and study in oceanography in cooperation with the staff of the Skidaway Institute of Oceanography at Savannah, Georgia. Students who specialize in oceanography conduct their thesis research at Skidaway after completing course work at Georgia Tech.

Undergraduate Program

The geophysical sciences are multidisciplinary with a strong dependence on the basic physical sciences, engineering, and mathematics; therefore, undergraduate students interested in the geophysical sciences should work toward a bachelor's degree in one of these disciplines. An undergraduate enrolled in another Georgia Tech school may develop a substantial background in the geophysical sciences by proper choice of electives within his or her own degree program. For example, the School of Physics recommends a specific set of upper-level courses for physics majors who are interested in geophysics.

A certificate program is available for students who take a systematic series of courses in the geophysical sciences. Certificates are available for course work in three areas: geochemistry, geophysics, and engineering geology. Listings of the requirements for these certificates are available in the Catalog of the School of Geophysical Sciences.

Master's Degree Programs

The School tailors programs of study to the background and interests of each student entering the School of Geophysical Sciences. In order to pursue the courses that may be accepted as part of a graduate study program in geophysical sciences, most students will need a background that includes introductory geology and a minimum of one year of university-level courses in mathematics, chemistry, and physics. Students who enter without this background must take some remedial work without graduate credit.

In order to qualify for the degree Master of Science in Geophysical Sciences, a student must have completed a specific set of graduate courses in geophysical sciences and must complete an approved thesis. Students who wish to include more course work in a special technical area may pursue a program of study that does not meet all the requirements for the designated master's degree. Such a program of study, approved by the faculty of the School, will lead to the degree Master of Science.

Graduate students in the School of Geophysical Sciences can qualify under the Multidisciplinary Program in Mineral Engineering by electing certain mining and mineral courses (see the section "Multidisciplinary Programs in Engineering" under the description of the College of Engineering in this catalog).

Doctoral Program

Persons with a strong background in the basic sciences and mathematics, who show a capability for high achievement in research in the geophysical sciences, may enter a program of study leading to the doctoral degree. A wide range of individual programs is available, owing to the multidisciplinary nature of the geophysical sciences.

Courses of Instruction

GEOS 1000. Introduction to Earth Science
3-0-3. A survey of planetary science, atmospheric science, and oceanography giving general insight into the nature of man's environment.

GEOS 2100. General Geology

GEOS 2102. General Geology Laboratory
0-3-1. Corequisite: GEOS 2100. Exercises on minerals, rocks, topographic maps, and geologic maps.

GEOS 2300. Survey of Oceanography
3-0-3. Selected topics from geological, physical, chemical, and biological oceanography, marine technology, marine environment, resources from the sea. Relationships between man and the sea.

GEOS 2750. Physics of the Weather
3-0-3. An introductory treatment of the application of the basic physical laws to the understanding of weather phenomena. The main weather features will be descriptively developed. Cross-listed as PHYS 2750.

GEOS 3000. Earth Resources
3-0-3. Prerequisite: GEOS 2100. A study of Earth's physical resources—fresh water, land (soils), minerals, and fuels—emphasizing the geologic origin, geographic distribution, and future availability of the resources.

GEOS 3100. History of the Earth

GEOS 3400. Mineralogy
3-3-4. Prerequisite: GEOS 2102 or consent of Department. Crystal bonding and symmetry, crystal structure and crystal chemistry, application to geologically important minerals. Laboratory devoted to crystallography, hand specimen identification, X-ray diffraction.

GEOS 3410. Optical Mineralogy
1-3-2. Prerequisite: GEOS 3400. A brief introduction to the use of the polarizing microscope for the identification and study of rocks and minerals.

GEOS 3500. The Earth-Moon System

GEOS 4100. The Influence of Man's Activities on the Global Environment
3-3-4. Prerequisite: GEOS 2100. The interacting equilibrium of atmosphere, hydrosphere, biosphere, and lithosphere. The interfering effects of man's activities on the cyclic equilibria on the earth.

GEOS 4150. Petrology of the Sedimentary Rocks
2-3-3. Prerequisite: GEOS 3410. Texture, composition and structure of sediments and sedimentary rocks, sedimentary processes (hydraulics and aqueous geochemistry), analysis of sedimentary environments.

GEOS 4200. Structural Geology
3-3-4. Prerequisite: GEOS 2102. Structures produced by rock deformation during tectonic and metamorphic activity. Primary structural features. The laboratory will include several field trips.

GEOS 4250. Engineering Geology
3-3-4. Prerequisite: GEOS 2100. Applications of geological science to problems of civil engineering.

GEOS 4300. Introduction to Physical and Chemical Oceanography
3-0-3. Prerequisite: GEOS 2100 or consent of Department. Ocean geometry, physical properties of sea water, water movements and energy fluxes, sediments, marine geophysics, marine geophysics and tectonics, ocean history.

GEOS 4301. Applied Oceanography
3-6-5. Prerequisites: GEOS 2100 and consent of Department. The aspects of physical, chemical, and biological sciences which are marine-oriented as applied to specific problems in the ocean and its environs. Collection and interpretation of field data stressed, utilizing vessels and equipment of the Skidaway Institute of Oceanography.

GEOS 4500. Introduction to Geophysics
3-0-3. Prerequisite: GEOS 2100. General survey of terrestrial geophysics. Topics discussed include the earth's seismicity, internal structure, shape, gravity, magnetic field, paleomagnetism, heat flow, and global tectonics.

GEOS 4550. Applied Geophysics
3-3-4. Prerequisites: GEOS 2100, PHYS 2123. Theory of electrical, magnetic, gravity, seismic refraction and reflection exploration methods. The laboratory provides exercises in instrumentation and data interpretation.

GEOS 4551. Seismic Reflection Methods in Exploration Geophysics
3-0-3. Prerequisite: MATH 2309 or consent of instructor. Seismic wave propagation, ray theory, and refraction data interpretation. Seismic reflection data acquisition and interpretation techniques. Application of seismic data to the search for oil.

GEOS 4552. Potential Methods in Exploration Geophysics

GEOS 4600. Introduction to Geochemistry
3-3-4. Prerequisites: GEOS 2100, CHEM 2113. Distribution and behavior of the chemical elements and natural compounds in the earth, its waters, and its atmosphere. Application of chemical principles to geologic processes.

GEOS 4650. Introduction to Atmospheric Sciences
3-0-3. Prerequisites: CHEM 1102, MATH 2309, PHYS 2123, thermodynamics.

Curricula and Courses of Instruction: Geophysical Sciences
Introduction to atmospheric physics, chemistry and dynamics, with emphasis on the interdisciplinary nature of atmosphere science, and man's interaction with the environment.

**GEOS 4801. Special Topics**
1-0-1.

**GEOS 4802. Special Topics**
2-0-2.

**GEOS 4803. Special Topics**
3-0-3.

**GEOS 4804. Special Topics**
4-0-4.

**GEOS 4805. Special Topics**
5-0-5.

**GEOS 4900. Special Problems**
Credit hours to be arranged.

**GEOS 6049. Geophysics I—Deformation of Earth Materials**
3-0-3. Prerequisite: consent of Department.
A theoretical survey of the elastic and inelastic behavior of the earth's materials and implications for tectonics, heat flow, and the earth's interior.

**GEOS 6051. Geophysics II—Gravity**
3-3-4. Prerequisite: consent of Department. An intense theoretical survey of terrestrial geophysics. Topics include potential theory, shape of the earth, and physical geodesy.

**GEOS 6062. Geophysics III—Geomagnetism and Paleomagnetism**
3-0-3. Prerequisite: GEOS 6051 or consent of Department. Topics include magnetohydrodynamics, origin and description of Earth's magnetic field, rock magnetism, remanent magnetism, geophysical evidence for global tectonics and tectonic mechanisms.

**GEOS 6100. Clay Mineralogy**
3-0-3. Prerequisite: consent of Department. The composition and structure of clay minerals, physical and chemical properties, X-ray identification, geologic distribution, and significance, origin.

**GEOS 6110. Advanced Clay Mineralogy**
2-3-3. Prerequisite: GEOS 6100. Clay-water relations; cation exchange; effects of crystal structure and composition on physical and chemical properties, X-ray, electron microscope, and other techniques.

**GEOS 6150. Sedimentary Geology**
3-3-4. Prerequisite: GEOS 6100. Composition, texture and structure of sedimentary rocks, sedimentary processes, diagenesis, environments of deposition, stratigraphy of sedimentary rocks.

**GEOS 6160. Stratigraphy and Sedimentation**
3-0-3. Prerequisite: GEOS 6150. Continuation of GEOS 6150 with emphasis on sedimentary environments, recent and ancient. Principles of correlation, stratigraphic mapping, and stratigraphic analysis.

**GEOS 6180. Geology of Ground Water**
3-0-3. Prerequisite: GEOS 2100. Relates ground water quality and availability to the geology of specific areas.

**GEOS 6210. Global Tectonics**
3-0-3. Prerequisite: GEOS 4200. Geologic aspects of the new global tectonics.

**GEOS 6220. Advanced Structural Geology**
3-0-3. Prerequisite: GEOS 4200. Solution of problems in civil engineering.

**GEOS 6250. Advanced Engineering Geology**
3-0-3. Prerequisite: GEOS 4200 or consent of instructor. Application of geosciences to the examination and solution of problems in civil engineering.

**GEOS 6300. Principles of Physical Oceanography**
3-0-3. Prerequisite: consent of Department. Temperature, salinity, and density in the oceans. Dynamics of ocean currents. Theory of ocean waves. Selected topics with application to coastal and estuarine circulation.

**GEOS 6310. Principles of Chemical Oceanography**
3-0-3. Prerequisite: CHEM 3412, GEOS 4300, or consent of Department. Brief overview of the chemistry of sea water and marine sediments. Detailed discussion of selected topics.

**GEOS 6400. Igneous Petrology**
3-3-4. Prerequisite: GEOS 6425. Microscopic study, classification, physical chemistry, and evolution of igneous rocks.

**GEOS 6425. Geologic Phase Diagrams**
3-0-3. Prerequisite: CHEM 2113, GEOS 4600, or consent of Department. Practical application of available phase diagrams to problems in metamorphic and igneous petrology. Phase rule is used extensively.

**GEOS 6450. Metamorphic Petrology**
3-3-4. Prerequisite: GEOS 6425. Study and classification of chemical and physical changes induced in rocks upon metamorphism. Microscopic laboratory study.

**GEOS 6510. Analytical Methods in Geophysics I**
3-3-4. Prerequisite: GEOS 6520. Theory and practice in the application of numerical analysis methods to geophysical data. Topics include information theory in seismology and harmonic analysis of potential data.

**GEOS 6520. Analytical Methods in Geophysics II**
3-3-4. Prerequisite: consent of instructor. Hankel transforms and applications; electrical soundings. Propagation of plane waves in nonhomogeneous media, the W.K.B.1 approximation, magneto-telluric soundings. Radiation of a dipole over a layered conducting half space, electromagnetic soundings.

**GEOS 6550. Observational Seismology**
3-3-4. Prerequisite: GEOS 4500. A study of the nature of earthquake motion and the damage it causes. The laboratory provides exercises in the interpretation of seismograms.

**GEOS 6560. Theoretical Seismology**
3-3-4. Prerequisites: MATH 4320, 4581, 4582, GEOS 6550. Theory of elastic wave propagation in the earth. Topics include reflection of waves, surface waves, and Cagniard theory of body waves.

**GEOS 6600. Geologic Phase Diagrams**
3-0-3. Prerequisite: CHEM 3412, GEOS 2100, or consent of Department. Reactions of minerals in waters on or near the surface of the Earth.

**GEOS 6610. Organic Geochemistry**

**GEOS 6620. Nuclear Geochemistry**

**GEOS 6625. Stable Isotope Geochemistry**
2-0-2. Prerequisite: CHEM 2113, GEOS 3400. Variations in isotopic composition of the elements owing to isotopic effects in natural physical and chemical processes. Application of isotope ratio measurement to geochmistry, hydrology, oceanography, and paleoclimatology.

**GEOS 6750. Introductory Diffraction Studies**
2-6-4. Prerequisite: consent of Department. Introductory theory and practice of the most widely applied X-ray diffraction techniques. Identification, lattice parameters, textures, line breadth, and crystal orientation. Cross-listed with PHYS 4266.

**GEOS 6764. Ocean Acoustics**
3-0-3. Prerequisite: MATH 4582. Recommended: GEOS 4300, AE 6760. Propagation of sound waves in the ocean. Topics selected from stress-strain relationships, asymptotic ray theory, propagation in shallow and deep water, irregularities of the media and boundaries, sonar arrays. Crosslisted with ME 6764, ESM 6764.

**GEOS 6791. Atmospheric Turbulence**
3-0-3. Prerequisite: GEOS 4650, fluid dynamics. Introduction to turbulence, turbulent transport of moisture and heat, sources of turbulence in the atmosphere, the dynamics of turbulence, statistical description, correlation functions and the spectral dynamics of turbulence.
of marketable knowledge and skills for professional design and development careers in areas such as computer systems, programming systems and languages, networks, artificial intelligence, graphics, and databases. The second is preparation for graduate work in information and computer science.

In addition to the standard four-year plan, a five-year cooperative plan is offered for students who wish to combine their education with industrial experience.

The undergraduate program requires a total of 194 credit hours for graduation.

## Curriculum

### Freshman Year

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<th>Course</th>
<th>1st Q</th>
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<tr>
<td>ICS 1000 Information and Society</td>
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<tr>
<td>ICS 1001 Computing Facilities</td>
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<tr>
<td>ICS 1400 Introduction to Algorithms and Computing</td>
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<td>3-0-3</td>
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<tr>
<td>ICS 1401 Computer Programming and Problem Solving</td>
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<tr>
<td>ENGL 1001/2 Analysis of Literature and Language</td>
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<tr>
<td>Elective* English</td>
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<td>HIST 1001 (or 1002) History of the United States to 1865 (or from 1865 to the Present)</td>
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<td>MATH 1307/1308/1309 Calculus I, II, III</td>
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<td>Electives Laboratory Science</td>
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<td>Electives Physical Education</td>
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### Sophomore Year

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<tr>
<td>ICS 2150* Introduction to Discrete Structures</td>
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### Junior Year

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<tr>
<td>ICS 2200 Data Structures</td>
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<tr>
<td>ICS 2250 Technical Information Resources</td>
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<tr>
<td>ICS 2300 File Processing</td>
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<td>ICS 2601/2 Computer Organization and Programming I &amp; II</td>
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<td>MATH 2307/8 Calculus IV, V</td>
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<td>PHYS 2121 Particle Dynamics</td>
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<td>PHYS 2122 Electromagnetism</td>
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<td>PHYS 2123 Optics and Modern Physics</td>
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<td>ENGL 3020 Technical Writing</td>
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<td>LING 3004 Natural Language Processing</td>
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<td>MATH 3215 Problems in Probability and Statistics</td>
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<td>PHYS 3303/3304 General Psychology A, B</td>
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### Senior Year

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<tr>
<td>Electives* Non ICS Areas of Specialization</td>
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<tr>
<td>Electives Humanities</td>
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### Master's Program

The Master of Science program prepares students for professional careers in technical and technical-managerial positions and for continued studies at the doctoral level. A student may earn the ICS M.S. degree by either completing fifty quarter hours of approved course work or thirty-three hours of approved course work and a thesis, credited as follows:

**Without Thesis**
- Total Course Credit Hours: 50
- Minimum Credit Hours in ICS: 36
- Minimum Credit Hours (6000/8000 Level): 35
- Minimum Credit Hours (6000/8000 Level) in ICS: 27

**With Thesis**
- Total Credit Hours: 50
- Thesis Hours (7000): 17
- Total Course Credit Hours: 33
- Minimum Credit Hours in ICS: 24
- Minimum Credit Hours (6000/8000 Level) in ICS: 18

Within the fifty total credit hours, students must include ICS 6155, ICS 6410, ICS 6430, ICS 6450, ICS 6620, and ICS 6750 as part of their approved program of study unless they have previously taken courses that cover this material.

Undergraduate courses required for the ICS B.S. degree may not be used toward the ICS master's degree. In addition, no graduate credit will be given for 3xxx courses or lower level courses.

With the exception of thesis research, students must take all ICS M.S. degree coursework on a "letter-grade" basis. The maximum total credit hours of ICS 85xx (Special Problems) that may be applied toward the ICS M.S. degree is five. Additional degree requirements as specified by the Institute are listed in the section, "Information for Graduate Students."

Students applying for admission to the master's degree program must have earned a bachelor's degree from an accredited institu-
tion, preferably in computer science. Students lacking a strong background in computer science must be prepared to do substantial remedial work in order to qualify for full graduate standing. The M.S. degree program begins in the fall quarter of each academic year.

**Doctoral Program**

The doctoral program in the School of Information and Computer Science prepares exceptionally qualified individuals for research careers. Graduates receive the degree of Doctor of Philosophy for performance of original research resulting in a significant contribution to the discipline's body of knowledge.

The doctoral program has three phases that normally require a minimum of three years to complete. At the end of the first phase the student must be able to demonstrate basic knowledge of a spectrum of subject areas in computer and information science, as well as a high research potential. The second phase culminates in the formulation of a dissertation research proposal. Research and dissertation defense complete the program.

Students applying for admission to the doctoral program should offer evidence of exceptional scholastic ability, intellectual creativity, research motivation, and a strong background in computer science. Students lacking such background must be prepared to do substantial remedial work in computer science before attaining full graduate standing.

**Graduate Cooperative Program**

The School participates in the Graduate Cooperative Program, which is administered by the Office of Graduate Studies and Research. Details of the program are stated in the section, "Information for Graduate Students."

**Research Opportunities**

Involvement in the School's active research efforts is an important part of a student's education. These efforts include a broad range of activities in computer system architecture, programming languages and environments, software engineering, distributed operating systems, computer networks, database systems, computer graphics, VLSI systems, computer security, theoretical computer science, human factors in computer systems, artificial intelligence, cognitive science, systems theory, information science, information systems, and computer-supported instruction.

**Curricula and Courses of Instruction**

**Information and Computer Science**

Courses of Instruction

**ICS 1000. Information and Society**

1-0-1. The history and future of the information industry. Career paths in information and computer science.

**ICS 1001. Computing Facilities**

0-3-1. Introduction to the equipment and facilities of the school and the Office of Computing Services. Emphasis on the effective use of the time-sharing system.

**ICS 1400. Introduction to Algorithms and Computing**

2-3-3. First course on problem solving using computers. The concept and notation of algorithms. Problem analysis, development of algorithms and their implementation in PASCAL.

**ICS 1401. Computer Programming and Problem Solving**

3-0-3. Prerequisite: ICS 1400. A continuation of the development of the discipline in problem program design and programming style using the advanced features of the PASCAL language. Credit not allowed for both ICS 1401 and ICS 2100.

**ICS 1700. Digital Computer Organization and Programming**

3-0-3. Algorithmic processes of problem solving, properties of algorithms, development of algorithms for the solution of numerical and non-numerical problems. The FORTRAN programming language. No credit for ICS majors.

**ICS 2000. Programming and Problem Solving Using PASCAL**

3-0-3. Prerequisite: ICS 1700 or equivalent. The programming language PASCAL is introduced. Extensive use is made of programming examples and assignments to develop effective programming skill. Credit not allowed for both ICS 1401 and ICS 2100.

**ICS 2150. Introduction to Discrete Structures**

3-0-3. Prerequisite: ICS 1308.

An introduction to concepts fundamental to the analysis of algorithms and their realizations. Topics included are induction, recursion, graphs, machines, Boolean algebras, and combinatorics.

**ICS 2200. Data Structures**

3-0-3. Prerequisites: ICS 1401 (or 2100), MATH 1308. Logical data structures and their representation. Processes on data structures, with emphasis on lists and trees.

**ICS 2250. Technical Information Resources**

1-0-1. Introduction to the literature and information services of science, engineering, and management. Effective use of the Georgia Tech library.

**ICS 2300. File Processing**

3-0-3. Prerequisite: ICS 2250. Introduction to the concepts and techniques for manipulating data on bulk storage devices. Term project.

**ICS 2601. Computer Organization and Programming I**

3-3-4. Prerequisites: ICS 1401 or 2100. Introduction to computer organization, machine language programming, and assembly systems. Assembly language programming techniques.

**ICS 2602. Computer Organization and Programming II**

3-3-4. Prerequisites: ICS 2200, 2601, PHYS 2122. Intermediate treatment of computer organization and machine programming. Input/output processing, memory and processor structures, and interfacing. Basic computer logic design, gate minimization, cost evaluation, and combinatorial circuits.

**ICS 3140. Introduction to Discrete Systems**

3-0-3. Basic system concepts; modeling; general dynamical systems; state formalism; mathematical models of linear dynamical systems; analysis and synthesis of linear automata; applications.

**ICS 3150. Introduction to Mathematical Logic**

3-0-3. Prerequisite: ICS 2150. Introduction to formal systems for the logical appraisal of inferences, including quantification and identity theory, relational interpretation, first order languages, soundness, and completeness.

**ICS 3155. Introduction to Theory of Computing I**

3-0-3. Prerequisite: ICS 2150. Study of fundamental concepts in the formal theory of automata emphasizing finite state machines. Turing machines and computational power of machines.

**ICS 3300. Introduction to Software Development**

3-0-3. Prerequisites: ICS 2300, 3602. Introduction to current techniques used in large-scale software development. Topics include requirements analysis, functional specification, systems design, implementation, testing, and maintenance.

**ICS 3360. Introduction to Artificial Intelligence**

3-0-3. Prerequisite: ICS 3422. Introduction to cognitive modeling, automatic problem solving, natural language processing, machine perception, and robotics.

**ICS 3400. Automatic Data Processing**

2-3-3. Prerequisite: ICS 1400 or 1700 or equivalent. Development of algorithms for the solution of business oriented problems. File structure organization and processing of data on external storage devices. The COBOL programming language.

**ICS 3422. Survey of Programming Languages**

3-0-3. Prerequisite: ICS 2200. Study and comparison of language features and programming techniques using a variety of programming languages such as PASCAL, FORTRAN, PL/1, ALGOL, LISP, SNOBOL, APL, and COBOL.

**ICS 3500. Information Systems**

3-0-3. Prerequisites: ICS 1401 or 1700. Empirical methodology of analysis and design of computer-based information systems, and its relationship with the definition of objectives, planning, analysis design, implementation, and evaluation of such systems.

**ICS 3510. Computer-Oriented Numerical Methods**

2-3-3. Prerequisites: ICS 1401 or 1700, MATH 1309. Introduction to computer oriented numerical methods for error analysis, function evaluation, solution of systems of equations, curve-fitting, interpolation, numerical integration, and differentiation.

**ICS 3602. Computer Organization and Programming**

3-3-4. Prerequisite: ICS 2602. Basic treatment of computer system software, including operating systems, assemblers, macro processors, compilers, interpreters, linkers, and loaders. Sequential logic, microprocessor design and programming.

**ICS 4117. Introduction to Mathematical Linguistics**

3-0-3. Prerequisites: ICS 2150, LING 3004, MATH 3215. Application of statistical and algebraic approaches to the study of linguistic structures from the viewpoint of their utility to a wide range of problems.

**ICS 4120. Introduction to Information Processes I**

3-0-3. Prerequisites: ICS 2150, MATH 3215. Exploration of the information concept and its properties. Statistical theory of syntactic communication: information sources, information transmission, channel capacity and efficiency, coding, noisy communication channels.
ICS 4121. Introduction to Information Processes II 3-0-3. Prerequisites: ICS 2150, MATH 3215.
Computer methods of clustering, identification, systematization, and pattern recognition; empirical data processing, choice of measurement, feature selection, data reduction, optimality criteria; analysis of algorithms, applications.

ICS 4136. Problem Solving 3-0-3.
General approaches to problem solving, with emphasis on methods and techniques of formulating intuitive heuristics. Structure of problems and goals, generation of alternatives. Incomplete information.

ICS 4155. Introduction to Theory of Computing II 3-0-3. Prerequisites: ICS 2150, 2200.
Introduction to the mathematical analysis of computer algorithms, correctness, complexity, asymptotic lower bounds, efficient data structures, and combinatorial algorithms. NP-complete problems.

ICS 4250. Literature of Science and Engineering 2-3-3. Prerequisite: ICS 2250.
Study of the reference and bibliographic sources of scientific, engineering, and management literature, emphasizing strategies of manual and computer searching. Bibliographic project in student's discipline.

ICS 4342. Natural Language Processing 3-0-3. Prerequisite: ICS 3360.
Methodologies for designing systems that comprehend natural language. Topics include lexical analysis, parsing, interpretation, and generation of sentences; semantic representations, organization of knowledge and inference mechanisms.

ICS 4351. MIDS Methodology 3-0-3.
Methodology for the design and implementation of management information systems in industrial, business, and governmental organizations. Feasibility studies, system development, implementation, and evaluation. Project management.

ICS 4370. Information Storage and Retrieval 3-0-3. Prerequisites: ICS 2602, MATH 3215.
Computer-aided organization and retrieval of bibliographic and natural-language information. Topics include statistical, syntactic, and logical analysis of information content, evaluation of retrieval effectiveness.

ICS 4380. Data Communications 3-0-3. Prerequisite: ICS 3602.
An introduction to data communications for computers and computer terminals, including communications media, codes, data transmission, multiplexing, communications software, protocols, switching, and simple networks.

Introductions to computer graphics: hardware, database, and software organizations for graphics; 2D and 3D transformations; fundamentals of vector and raster graphics; programming project implementing a subset of the graphics algorithm.

ICS 4410. Introduction to Compilers 3-0-3. Prerequisites: ICS 3422, 3602.
Study of the basic techniques of compiler design and implementation with consideration of the implementation characteristics of widely used programming languages.

ICS 4430. Introduction to Operating Systems 3-0-3. Prerequisite: ICS 2100 (or equivalent), 3602.
A qualitative introduction to operating systems including multiprogramming concepts, resource allocation and management, other functions performed, and operating system implementation.

ICS 4450. Introduction to Data Base Design 3-0-3. Prerequisites: ICS 2300, 3602.
Introduction to logical and physical structures of computer data base systems. Topics include data models, data base theory, query processing, usage of relational and network models of data bases.

ICS 4601. Computer Systems Laboratory I 1-6-3. Prerequisite: ICS 3602.
Hands-on hardware experiments for ICS majors. Construction and programming of an operating micro-computer.

ICS 4602. Computer Systems Laboratory II 1-6-3. Prerequisite: ICS 3602.

ICS 4620. Microprogramming 2-3-3. Prerequisite: ICS 3602.
Introduction to the fundamental concepts and applications of microprogramming and microprogrammable systems including a study of emulation, microprogramming languages, and microprogrammable computers.

ICS 4651. Design Project I 0-3-1. Prerequisite: consent of School.
First quarter of an undergraduate thesis sequence consisting of an analytic or empirical investigation in an approved area of information and computer science. Proposal preparation.

ICS 4652. Design Project II 0-3-1. Prerequisite: ICS 4651.
Second quarter of undergraduate thesis sequence. System analysis and design.

ICS 4653. Design Project III 0-12-4. Prerequisite: ICS 4652.
Third quarter of undergraduate thesis sequence. System implementation and final project report.

ICS 4754. Models of Human Information Processing 3-0-3. Prerequisites: PSY 3304, ICS 1700 or equivalent.
General and unified approaches to psychological and computer modeling of human information processes. Emphasis on neural, sensory, memory, semantic, and conceptual processing. Also listed as PSY 4754.

Examination of human factors in the software design and application process from initial requirement and specification statements to coding, testing, implementation, and maintenance. Also listed as PSY 4756.

ICS 4801-2-3-4-5-6. Special Topics 3-0-3.
Credit hours equal last digit of course number. Prerequisite: consent of School.
Course of timely interest to the profession, conducted by resident or visiting faculty.

Credit to be arranged. Prerequisite: consent of School. Individual investigation of significant areas of information and computer science. Guided study and research.

Scientific method; subject of information science; sign processes; information and tests; measurement and information measures; laws and theories of information science; applications to information technology.

ICS 6111. Information Measures 3-0-3. Prerequisites: ICS 2150, MATH 3215.
Introduction to the mathematical analysis of computer algorithms, correctness, complexity, asymptotic lower bounds, efficient data structures, and combinatorial algorithms. NP-complete problems.

ICS 6140. Introduction to the Mathematical Analysis of Computer Algorithms 3-0-3. Prerequisites: ICS 3300, PSY 3304.
Examination of human factors in the software design and application process from initial requirement and specification statements to coding, testing, implementation, and maintenance. Also listed as PSY 4756.

System analysis and design implemented related to compiler design and implementation: deterministic parsing, table processing, code generation, syntax-directed compiling, global optimization.

Basic techniques for analyzing and designing efficient algorithms. Upper and lower time-space bounds for data structure, sorting and combinatorial problems, algebraic algorithms.

ICS 6156. Complexity of Computation 3-0-3. Prerequisite: ICS 3150 or 6155.
Advanced techniques for analyzing the time space complexity of natural computational problems; proving the tractability or intractability of problems from algebra, combinatorics, computer science, geometry, and number theory.

Advanced treatment of the theory of computability. Topics include recursive functions, recursively enumerable sets and relations, degrees of unsolvability, the recursion theorem and computational complexity.

Organization, operation, and management of the information industry. Information economics, software companies, information brokers. Vendor relationships. Issues of ethics, privacy, security, and auditing.

A study of the knowledge and inferences necessary for understanding; memory organization; representation of episodes; question answering; reconstructive memory.

ICS 6347. Computer-Aided Modeling
3-0-3. Prerequisites: MATH 3215, ICS 2602.


ICS 6360. Artificial Intelligence
3-0-3. Prerequisite: ICS 3360.

Advanced study of topics from heuristic search, automatic theorem proving, semantic information processing, representation theory, and other current areas.

ICS 6363. Pattern Recognition
3-0-3. Prerequisite: MATH 3215 or equivalent.

Basic principles and methods of statistical pattern recognition; decision functions; pattern classifications by distance and likelihood functions; trainable pattern classifiers; feature extraction.

ICS 6370. Information Control Methods
3-0-3.

Study of methods of information control. Including assessment of information needs, data collection and reduction, manual and automatic indexing, abstracting and classification, evaluation and performance.

ICS 6380. Computer Networks
3-0-3. Prerequisites: ICS 4380, 4430.

In depth examination of the design and operation of computer networks covering computer hardware and software, designs and design requirements and communication subsystems.

ICS 6410. Computer Language Design
3-0-3. Prerequisite: ICS 3422 or 4410.

Description, structure, and design philosophies of high level programming languages. Design aspects of names and types, data and control structures, and features for data abstraction and modularity.

ICS 6412. Syntax Directed Compilation
3-0-3. Prerequisite: ICS 4430.

Detailed study of compiler implementation techniques, including table-driven syntax analysis, translation to intermediate language, optimization, and object code generation.

ICS 6430. Computer Operating Systems
3-0-3. Prerequisites: ICS 2100 (or equivalent), 4430.

A quantitative course of computer operating system functions emphasizing implementation techniques including sequential and concurrent processes, processor and storage management, scheduling and protection.

ICS 6431. Design of Computer Operating Systems I
1-6-3. Prerequisite: ICS 6430.

A major systems programming project involving the modification or extension of an existing operating system component and an evaluation of the results.

ICS 6435. Computer Systems Evaluation
3-0-3. Prerequisites: MATH 3215, ICS 4430.

Methods of evaluating performance of large-scale computer systems, with emphasis on performance analysis through simulation, queuing models, and measurement.

ICS 6450. Data Base Design
2-3-3. Prerequisites: ICS 4155, 4450.

Study of the state-of-the-art of data base design. Approaches to database theory and optimization of data base algorithms. Term project.

ICS 6530. Graph Theory
3-0-3. Prerequisite: ICS 2150.

Graph structure and algorithms, including trees, circuits, planarity, enumeration, combinatorics, network flows, and algorithm complexity, with applications in information and computer science.

ICS 6555. Queuing Theory and Applications I
3-0-3. Prerequisites: MATH 3215, ICS 4430.

Queuing theory and its application in computer performance evaluation, operating systems design, telecommunications, and operations research.

ICS 6556. Queuing Theory and Applications II
3-0-3. Prerequisite: ICS 6555.

Continuation of ICS 6555 emphasizing current research problems. Suitable for dissertation research are discussed.

ICS 6600. Advanced Small Scale Computer Systems
1-6-3. Prerequisite: ICS 3602.

The design and application of software and hardware for actual computer systems is introduced through hands-on laboratory experience with hardware modules, micro-computers, and interface sub-systems.

ICS 6620. Advanced Computer Organization
3-0-3. Prerequisite: ICS 3602.

Studies of computer system organizations: advanced input output systems, multiprocessors, pipeline processors, other parallel systems.

ICS 6750. Human-Computer Interface
3-0-3. Prerequisite: consent of School.

Human-computer interface is considered in terms of user-system compatibility. Concepts in human factors and interface design are covered in relation to capabilities and limitations of both humans and computers. Also listed as PSY 6750.

ICS 7000. Master's Thesis
Credit to be arranged. Prerequisite: consent of School.

ICS 7115. Philosophy of Language
3-0-3. Prerequisite: ICS 6116 or 6117 or consent of School.

Study of selected topics in linguistics arising from philosophic discussion of language. Emphasis on foundations of language.

ICS 7999. Preparation for Doctoral Qualifying Exams
Credit to be arranged. Prerequisite: consent of School.

ICS 8111-2-3-4-5-6. Special Topics
Credit hours equal last digit of course number. Prerequisite: consent of School.

Special topics of current interest. Treatment of new developments in various areas of information and computer science.

ICS 8501-2-3. Special Problems
Credit to be arranged. Prerequisite: consent of School.

Small group or individual investigation of advanced topics in information and computer science. Guided study and research. Maximum of five credit hours allowed toward the ICS M.S. degree.

ICS 8999. Doctoral Thesis Preparation
Credit to be arranged. Audit only. Prerequisite: consent of School.

ICS 9000. Doctoral Thesis
Credit to be arranged. Prerequisite: consent of School.

School of Mathematics
Established in 1952

Director and Regents' Professor—William F. Ames; Assistant Director and Associate Professor—Dar-Veig Ho; Coordinator of Graduate Programs and Professor—James V. Herod; Coordinator of Undergraduate Programs and Associate Professor—Kevin T. Phelps; Computer Coordinator and Professor—William J. Kammerer; Professors—Michael F. Barnsley, Johan G. Belinfante, George L. Cain, Jr., Bertram M. Drucker (emeritus), Richard A. Duke, Jamie J. Goode, Les A. Karlovitz, Robert H. Kasriel (emeritus), Gunter H. Meyer, John D. Neff, Daniel A. Robinson, Michael P. Stallybrass, Yung L. Tong, James W. Walker (emeritus); Associate Professors—Alfred D. Andrew, Marc Berger, Nathaniel Chafee, Mark J. Christensen, Stephen G. Demko, Donald M. Friedlen, William L. Green, Theodore P. Hill, Roger D. Johnson, Robert P. Kertz, John P. Line, James M. Osborn, E. Juanita Pitts, Ronald W. Shenk, Alan D. Sloan, William R. Smythe, Jr., Jonathan E. Spingarn, M. Carl Spruill, Ernst Stephan; Assistant Professors—James C. Crabtree (visiting); John H. Elton, Joel C. Fowler, Jeffrey Geronimo, Evans Harrel, William J. Layton, Thomas D. Morley (visiting), Kathleen Spear.

General Information
Mathematics forms an integral part of the curricula of most students at Georgia Tech. Consequently, the School of Mathematics offers a wide range of courses serving students in the various engineering, science, and management disciplines. In addition, the School offers programs of study leading to the bachelor's, master's, and doctoral degrees in mathematics. Such programs of study serve as preparation for mathematics careers, professional schools, and graduate studies.

In addition to basic courses in mathematics, the School offers a variety of specialized courses at the undergraduate and graduate levels, emphasizing areas related to the research activities of the faculty. At present, these include mathematical analysis, applied mathematics, differential equations, scientific computing, probability, statistics, combinatorics, mathematical physics, topology, and algebra.

The School of Mathematics has excellent computer facilities that are used in conjunction with an increasing number of courses and programs of study.

A cooperative plan for students who wish to combine practical experience with academic work is now available for mathematic majors.

Information supplementary to this catalog which may be useful to students planning or considering a program of study in mathematics is available in the School office.

Undergraduate Program
Reflecting the scientific environment at Georgia Tech, the bachelor's program in mathematics trains students in the traditional core mathematics curriculum, as well as in its applications. The undergraduate program is sufficiently flexible to accommodate the wide variety of interests of undergraduate majors, and yet by its scientific breadth, it prepares the student for the extensive employment opportunities that exist for applied mathematicians.

Students are encouraged to develop an expertise in another field related to mathematics. This can be accomplished by develop-
A program of study leading toward a master's degree should include analysis consisting of MATH 6317, 6318, 6320, 6580, and the modeling course MATH 6510. In addition, students should take six hours of course work at the 3000 level or higher outside of the School of Mathematics. The program should also include either a thesis (seventeen hours) and seven additional hours of course work at the 4000 level or higher, or twenty-four hours of course work at the 4000 level or higher, including nine hours of concentration in some field of mathematics, three hours in numerical analysis, and three hours in probability, statistics, or stochastic processes (unless the student has previously had such training) and a sufficient number of hours at the 6000 level or higher to ensure that the program includes a total of at least thirty-five hours at this level.

Students must maintain an overall grade point average of at least 2.7 and receive a grade of C or better in each mathematics course in the program of study.

Before admission to candidacy for the master's degree, each student must pass an oral comprehensive examination. Most applicants holding the bachelor's degree are urged to enter the master's degree program before seeking admission to the doctoral program.

Students with the master's degree or equivalent may apply for the doctoral program. This program requires seventy-seven hours of course work beyond the undergraduate degree with at least five hours in real, functional, complex analysis, algebra, topology, and mathematical modeling. Fifteen of these hours must be taken outside the School of Mathematics in the student's minor field of study. Students must maintain an overall grade point average of 2.7 and a grade of C or better in each course of the program of study.

Prior to admission to candidacy for the doctoral degree, each student must pass comprehensive examinations in each of four areas of mathematics selected in part by the student. Also, doctoral candidates must demonstrate a reading knowledge of one language chosen from French, German, and Russian and satisfy the Institute require-

## Curriculum

### Freshman Year

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<thead>
<tr>
<th>Course</th>
<th>1st Q.</th>
<th>2nd Q.</th>
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<td>MATH 1307-8-9</td>
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<td>Calculus I, II, III</td>
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<td>ENGL 1001-2</td>
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<tr>
<td>Analysis of Literature and Language</td>
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<td>PHYS 2121</td>
<td>4-3-5</td>
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<tr>
<td>Particle Dynamics</td>
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<td>ICS 1400-1</td>
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<td>Physical Education</td>
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### Sophomore Year

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<td>MATH 2307-8</td>
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<td>Calculus IV, V</td>
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<td>MATH 3308</td>
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<tr>
<td>Differential Equations</td>
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<td>5-0-5</td>
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<td>MATH 3012</td>
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<tr>
<td>Applied Combinatorics</td>
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<td>MATH 3215</td>
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<tr>
<td>Probability and Statistics</td>
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<td>PHYS 2122-3</td>
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<td>Electives</td>
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### Junior and Senior Years

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<td>1. MATH 4101, 4301, 4311, 4312, 4313, 4320, 4640</td>
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<tr>
<td>2. PHYS 3121</td>
<td>5</td>
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<tr>
<td>3. Course work at or above the 3000 level in one degree-granting school other than mathematics</td>
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<tr>
<td>4. Mathematics courses at or above the 4000 level</td>
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<tr>
<td>5. Humanities and social science courses.</td>
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<td>The degree program must include either a year sequence in a modern language, or nine additional hours of English</td>
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<td>6. Free electives</td>
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<td>Total</td>
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</table>

### Graduate Programs

The School of Mathematics offers opportunities for study in a wide range of mathematical disciplines. First year graduate sequences include algebra, analysis, differential equations, numerical analysis, probability, statistics, and topology in addition to courses in methods of applied mathematics.

Any English course which carries humanities credit.
1 PHYS 2141-2-3 may be substituted for 2121-2-3 respectively.
1 ICS 1700 or EE 1010 and ICS 2100 may be substituted.
1 Institute requires eighteen hours of humanities credit and eighteen hours of social science. See "Information for Undergraduates" at the beginning of the catalog.
MATH 1710. College Algebra and Trigonometry
5-0-5. Prerequisite: entrance algebra. No credit toward graduation for engineering, science, or architecture degrees.
The function concept, exponential, logarithmic and trigonometric functions, theory of equations including trigonometric equations.
Text: at the level of Keedy and Bittinger, *Algebra and Trigonometry*.

MATH 1711. Mathematics for Management I
5-0-5. Prerequisite: MATH 1111. Linear equations and straight lines, matrices, linear programming, sets and counting, probability and statistics.

MATH 1712. Mathematics for Management II
5-0-5. Prerequisite: MATH 1711. Difference equations and the mathematics of finance, functions, the derivative, applications of the derivative, techniques of differentiation. Credit is not allowed for both MATH 1712 and 1307 except in MGT degree programs.

MATH 1713. Mathematics for Management III
5-0-5. Prerequisite: MATH 1712 or 1307. The exponential and natural logarithm functions with applications to exponential growth and decay and compound interest, integration, functions of several variables including partial derivatives, maxima and minima of functions of several variables. Lagrange multipliers and constrained optimization. Credit is not allowed for both MATH 1713 and MATH 1308 except in MGT degree programs.

MATH 2012. Boolean Algebra and Applications
3-0-3. Prerequisite: MATH 1307 or 1711. Introduction to discrete algebraic structures such as partial orders, lattices, and Boolean algebras, including the algebra of sets and propositional logic with applications to circuits.
Text: at the level of Mendelson, *Boolean Algebra and Switching Circuits*.

MATH 2307. Calculus IV
5-0-5. Prerequisite: MATH 2306. Linear algebra, vector independence, bases, eigenvalues and eigenvectors, partial derivatives, differentiable functions, gradient, maximum and minimum problems.
Text: at the level of Grossman, *Calculus Part Two*.

MATH 2308. Calculus V
5-0-5. Prerequisite: MATH 2307. Multiple integration, line and surface integrals, integral theorems and applications; infinite series, Taylor's theorem.
Text: at the level of Thomas and Finney, *Calculus and Analytic Geometry*.

MATH 2309. Differential Equations
5-0-5. Prerequisite: MATH 2308. Linear and elementary nonlinear differential equations and physical applications, systems of differential equations, series solutions. Numerical methods emphasized.
Text: at the level of Sanchez, *Differential Equations*.

MATH 2317-8. Honors Calculus IV, V
5-0-5 each. A continuation of MATH 1317, 1318, 1319. The coverage parallels that of MATH 2307-8.

MATH 2501-02-03-04-05. Special Topics
1-0-1 through 5-0-5 (respectively). Prerequisite: none. Courses on special topics of current interest in mathematics.

MATH 3012. Applied Combinatorics
3-0-3. Prerequisite: MATH 1308 or 1712. Elementary combinatorial techniques used in discrete problem solving. Topics include basic counting methods, graph and network models, related algorithms for searching and selecting.
Text: at the level of Berman and Fries, *Introduction to Combinatorics*.

MATH 3110. Introduction to Higher Algebra
3-0-3. Prerequisite: MATH 2307 or 1713. Vector spaces, matrices, systems of linear equations, linear transformations and matrices, change of basis, characteristic roots and vectors, quadratic forms and diagonalization.
Text: at the level of Roberts, *Elementary Linear Algebra*.

MATH 3215. Problems in Probability and Statistics
5-0-5. Prerequisite: MATH 2308 or 1713. An introduction to probability with applications (see MATH 4215), including models and problems in statistical inferences. Credit is not allowed for both MATH 3215 and 4215.
Text: at the level of Meyer, *Introduction to Probability and Statistical Applications*.

MATH 3308. Differential Equations
5-0-5. Prerequisite: MATH 2308. Differential equations with linear algebra, matrix treatment of linear systems, characteristic roots, exponential matrix function, series method stressing equations of Bessel and Legendre.
Text: at the level of Rabenstein, *Elementary Differential Equations with Linear Algebra*.

MATH 3360. Introduction to Scientific Computing
3-0-3. Prerequisites: MATH 2307, and knowledge of computer programming.
Solution of problems in economics, science, and technology employing algorithms for linear and nonlinear equations, integration and ordinary differential equations. Student use of computers emphasized.

MATH 3709. Mathematics for System Engineering
3-0-3. Prerequisite: MATH 2308. Techniques for solving linear differential equations (and systems) with constant coefficients, e.g. with Laplace transform. Credit is not allowed for MATH 3709 and 3209 or 3308.
Text: at the level of Bronson, *Differential Equations*.

MATH 3710. Introduction to Statistics
5-0-5. Prerequisite: MATH 1308 or 1712. Basic concepts and tools of statistical analysis as used in data analysis and inference in the behavioral, life, managerial, and physical sciences.

MATH 3716. Statistics for Management Science
5-0-5. Prerequisites: MATH 2307 and MATH 3215. Unified approach to statistical inferences through decision methods, and to regression and experimental design through least squares. Topics are introduced with discipline-oriented problems.
Text: at the level of Walpole, *Introduction to Statistics*.

MATH 3801-02-03-04-05. Special Topics
1-0-1 through 5-0-5 (respectively). Prerequisite: none. Courses on special topics of current interest in mathematics.

MATH 4012. Discrete Algebraic Structures in Coding Theory
3-0-3. Prerequisites: MATH 2301, MATH 3012, or MATH 3212. Algebraic and combinatorial structures including finite fields, rings, finite geometries, designs, and codes are introduced. Use of these structures in constructing error-correcting codes is emphasized.

MATH 4038. Mathematical Logic
3-0-3. Prerequisite: Introduction to probability with applications to circuits. The propositional and predicate calculi, developed as formal systems of symbol manipulation, with attention to the related decision problems, recursive functions and automata.
Text: at the level of Stoll, *Introduction to Set Theory and Logic*.

MATH 4101. Introduction to Abstract Algebra I
3-2-4. Prerequisite: MATH 2308. An introduction to basic algebraic systems with emphasis on groups, rings and fields.
Text: at the level of Herstein, *Topics in Algebra*.

MATH 4102. Introduction to Abstract Algebra II
3-0-3. Prerequisite: MATH 4101. A continuation of MATH 4101 with emphasis on modules, polynomial rings and linear associative algebras.
Text: at the level of Herstein, *Topics in Algebra*.

MATH 4140. Theory of Groups
3-0-3. Prerequisite: MATH 4101. Basic topics from group theory including some representation theory.

MATH 4141. Introduction to Probability
3-0-3. Prerequisite: MATH 2308 or 1713. Introduction to probability theory with applications, discrete and nonrandom distributions, moments, laws of large numbers, central limit theorem with applications. Credit is not allowed for both MATH 4215 and 3215.

MATH 4220. Elementary Discrete-Time Stochastic Processes
3-0-3. Prerequisite: MATH 3215 or MATH 4215. Development of random walk, waiting-time processes, and other stochastic processes through a problem-oriented approach. Methods of solution include counting techniques, recurrence relations, and generating functions.

MATH 4221. Probability with Applications I
3-0-3. Prerequisite: MATH 3215 or 4215. Introduction to the Poisson process, renewal processes, and Markov chains.
Text: at the level of Ross, *Stochastic Processes*.

MATH 4222. Probability with Applications II
3-0-3. Prerequisite: MATH 4221. Introduction to continuous-time Markov chains, Brownian motion, and martingales.
Text: at the level of Ross, *Stochastic Processes*.

MATH 4225. Computer Usage in Probability
3-0-3. Prerequisites: MATH 3215 or MATH 4215 and ECS 1700. Study of probability distributions, limit laws, and applications through the use of digital computer. Probability and Monte Carlo methods applied to deterministic problems.

MATH 4230. Analysis of Probability Distributions
3-0-3. Prerequisites: MATH 2308 and MATH 3215 or equivalent. Theory and methods in probability are developed. Important distributions, transform methods, multivariate distributions, and limit theorems are introduced.

MATH 4241. Mathematical Statistics I
3-0-3. Prerequisites: MATH 2308 and either 3215 or 4215. Unified approach to statistical estimation and testing of hypotheses, including introduction to Bayesian methods. Exact and asymptotic sampling distributions. Applications.
Text: at the level of Hoel, Port and Stone, *Introduction to Statistical Theory*.

MATH 4242. Mathematical Statistics II
Text: at the level of Graybill, *Theory and Application of the Linear Model*. Mathematics
MATH 4245. Computer Usage in Statistics
3-0-3. Prerequisite: MATH 4241 and ICS 1700 or equivalent.

Mathematical description of statistical models and the use of statistical computer routines, especially SPSS. Statistical packages in data analysis, including data description, t-tests and one way ANOVA, plots and histograms, frequency tables, regression, ANOVA, ANACOVA, and non-parametric procedures.

Text: Appropriate statistical package manuals.

MATH 4251. Nonparametric Statistics
3-0-3. Prerequisite: MATH 4241 or 4215.

Goodness-of-fit tests, rank tests, tests of association, location tests, scale tests, asymptotic theory including use of Pitman efficiency.

Text: at the level of J. D. Gibbons, Nonparametric Statistical Inference.

MATH 4280. Elements of Information Theory
3-0-3. Prerequisite: MATH 4215 or 4215.

A mathematical approach to information theory, primarily through probability in finite sample spaces. Coding theorem for discrete memoryless channels. Decision schemes. Shannon's theorem.

Text: at the level of Ash, Information Theory.

MATH 4281. Elementary Decision Theory
3-0-3. Prerequisite: MATH 4241.


Text: at the level of Ferguson, Mathematical Statistics: A Decision Theoretic Approach.

MATH 4282. Introduction to Stochastic Processes
3-0-3. Prerequisite: MATH 4215 or 4215.


Text: at the level of Yaglom, Theory of Stationary Random Functions.

MATH 4283. Introduction to Game Theory
3-0-3. Prerequisite: one of MATH 2010, 3110, 4580 or consent of School.

Introduction to game theory with emphasis on zero-sum two person games, economic applications, connections with linear programming and decision functions.

Text: at the level of Drucker, Games of Strategy.

MATH 4301. Finite-dimensional Vector Spaces
3-2-4. Prerequisite: MATH 2308.


Text: at the level of Stoll, Linear Algebra.

MATH 4302. Applications of Finite-dimensional Vector Spaces
3-0-3. Prerequisite: MATH 4301.

Applications of MATH 4301 with topics selected from the areas of convex sets, positive matrices, quadratic forms, linear differential equations, and generalized inverses.

MATH 4308. Ordinary Differential Equations
4-0-4. Prerequisites: MATH 2309 or 3308, MATH 3110 and either 4311 or 4391.

Systems of differential equations, linear systems and phase space analysis, existence theory, stability of linear systems, Liapunow theorems, stability of automatic control systems.

Text: at the level of Braun and Nohel, Qualitative Theory of Ordinary Differential Equations.

MATH 4311. Introduction to Analysis I
3-2-4. Prerequisite: MATH 2309 or 3308 or equivalent.

Real numbers, order completeness, normed vector spaces and notions of completeness and compactness, functions and continuity, sequences and series.

Text: at the level of Bartle, The Elements of Real Analysis.

MATH 4312. Introduction to Analysis II
3-2-4. Prerequisite: MATH 4311.

Limits of functions, differentiation of functions of one variable, Reimann-Stieljes integral, improper integrals, absolute and conditional convergence, integrals of sequences and series.

Text: at the level of Bartle, The Elements of Real Analysis.

MATH 4313. Introduction to Analysis III
3-2-4. Prerequisite: MATH 4312.

Differentiation in R^n, local inverse function theorem, implicit function theorem, extremum problems and Lagrange multipliers, integration of R^n, change of variables in multiple integrals.

Text: at the level of Bartle, The Elements of Real Analysis.

MATH 4320. Complex Analysis
3-0-3. Prerequisite: MATH 2309 or 3308.

Topics for complex function theory, including contour integration and conformal mapping.

Text: at the level of Churchill, Complex Variables with Applications.

MATH 4347. Introduction to Partial Differential Equations I
3-0-3. Prerequisite: MATH 2309 or 3308.


Text: at the level of Williams, Partial Differential Equations.

MATH 4348. Introduction to Partial Differential Equations II
3-0-3. Prerequisite: MATH 2309 or 3308.


Applications.

MATH 4391. Topics in Advanced Calculus I
3-0-3. Prerequisite: MATH 2308.

Partial differentiation, applications of partial differentiation, infinite series, improper integrals, uniform convergence.

Text: at the level of Taylor and Mann, Advanced Calculus.

MATH 4392. Topics in Advanced Calculus II
3-0-3. Prerequisite: MATH 4391.

Continuation of MATH 4391. Main topic is integration and applications. Also, Riemann, Stieljes, multiple, line and surface integrals, and the gamma function.

Text: at the level of Taylor and Mann, Advanced Calculus.

MATH 4431. Introductory Topology
3-0-3. Prerequisite: MATH 4311 or consent of School.

This course provides background for use of topological methods in analysis. Metric spaces. Continuous transformation. Topological spaces.

Text: at the level of Kasriel, Undergraduate Topology.

MATH 4432. Introduction to Algebraic Topology
3-0-3. Prerequisites: MATH 4431 and 4101 or 4301.

Introduction to algebraic methods in topology. Inclusion homotopy, the fundamental group, covering spaces, simplicial complexes. Applications to fixed point theory and graph theory.

Text: at the level of Singer and Thorpe, Elementary Topology and Geometry.

MATH 4441. Differential Geometry
3-0-3. Prerequisite: MATH 2308.

The theory of curves and surfaces, including the first and second fundamental forms of a surface and topics related to them.

Text: at the level of O'Neill, Elementary Differential Geometry.

MATH 4580. Linear Programming
3-0-3. Prerequisite or corequisite: MATH 2308.

A study of the linear programming problem including the simplex method, duality, and sensitivity analysis with applications to matrix games, integer programming, and networks.

Text: at the level of Chvatal, Linear Programming.

MATH 4581. Advanced Engineering Mathematics
3-0-3. Prerequisite: MATH 2309 or 3308.

The Laplace transform and its properties, applications to physical systems involving the solution of ordinary and partial differential equations.

Text: at the level of Churchill, Operational Mathematics.

MATH 4582. Advanced Engineering Mathematics
3-0-3. Prerequisite: MATH 2309 or 3308.

Fourier series, boundary value problems for partial differential equations, applications of Legendre polynomials and Bessel functions.

Text: at the level of Powers, Boundary Value Problems.

MATH 4583. Vector Analysis
3-0-3. Prerequisite: MATH 2308.


Text: at the level of Davis, Snider, Introduction to Vector Analysis.

MATH 4584. Mathematical Methods in Continuum Mechanics
3-0-3. Prerequisite: MATH 2308.

An elementary tensorial treatment of various geometrical and mechanical concepts needed in the study of hydrodynamics, elasticity, and plasticity.

Text: at the level of Prager, Introduction to Mechanics of Continua.

MATH 4591. Introduction to Mathematical Programming
3-0-3. Prerequisite: MATH 2308.

Introduction to various linear and nonlinear optimization problems in finite-dimensional spaces. Mathematical properties of the objective function will be examined and appropriate algorithms developed.

Text: at the level of Cooper and Steinberg, Introduction to Methods of Optimization.

MATH 4640. Scientific Computing I
3-0-3. Prerequisites: MATH 2308 and knowledge of computer programming.

Topics include finding zeros of functions, direct and iterative methods for solving linear systems of equations, polynomial interpolation and numerical integration including Romberg and adaptive methods.

MATH 4641. Scientific Computing II
3-0-3. Prerequisite: MATH 4640 or consent of School.

Topics covered include solution of ordinary differential equations, non-linear systems of equations, eigenvalue problems, least squares and spline approximations.

MATH 4790. Introductory Review of the Elementary Calculus
10-6-9. Audit basis only. Prerequisites: consent of School and student's adviser.

Refresher course for beginning graduate students with calculus background who have been away from academic work for considerable time. Review of calculus through sophomore level.

MATH 4800. Special Topics
3-0-3. Prerequisite: consent of School.

This course enables the School of Mathematics to comply with requests for courses in special topics. Given upon sufficient demand.

MATH 4801-02-03-04-05. Special Topics
1-0-1 through 5-0-5 (respectively). Prerequisite: none.

Courses on special topics of current interest in Mathematics.

MATH 4999. Reading or Research
1 to 3 credits. Prerequisite: junior standing or above, consent of School.

Pass/fail basis only. Not more than seven hours can be counted toward bachelor's degree. At most three hours can be counted as mathematics elective.

MATH 6012. Combinatorial Methods
3-0-3. Prerequisite: graduate standing or consent of School.

Introduction to fundamental methods in graph theory, enumeration, and designs including the use of recurrence relations, generating functions, trees, circuits, matchings, and graph colorings.
MATH 6121. Modern Abstract Algebra I
3-0-3. Prerequisites: MATH 4101, 4301.
An introduction to algebraic systems with emphasis on group theory.
Text: at the level of Lang, *Algebra*.

MATH 6122. Modern Abstract Algebra II
3-0-3. Prerequisite: MATH 6121.
Rings, ideals and related concepts, field theory unique factorization.
Text: at the level of Lang, *Algebra*.

MATH 6123. Modern Abstract Algebra III
3-0-3. Prerequisite: MATH 6122.
Concept of the total matrix algebra. Introduction to linear associative algebras.
Text: at the level of Lang, *Algebra*.

MATH 6232. Probabilistic Methods in Sequential Decision Theory
3-0-3. Prerequisite: MATH 4221 or the equivalent.
Development of results in sequential decision theory through probabilistic concepts and reasoning. Emphasis on application of Markov chain and martingale theories.

MATH 6241-2-3. Probability I, II, III
3-0-3 each. Prerequisite: MATH 6317 or equivalent.
This sequence develops the probability basis requisite in modern statistical theories and stochastic processes. It includes a selection of topics from measure and integration theory, distribution functions, convergence concepts, Fourier integrals and central limit theory, conditional distributions and independence and random analysis.

MATH 6261. Mathematical Statistics
3-0-3. Prerequisite: MATH 4241 or consent of School.
This course provides a comprehensive introduction to the theory of mathematical statistics. Topics include estimation, confidence intervals, hypothesis testing, and linear models.

MATH 6267-8-9. Ordinary Differential Equations I, II, III
3-0-3 each. Prerequisites: MATH 3110, 4313.
This sequence of courses covers the theory and applications of ordinary differential equations. Topics include existence and uniqueness theorems, linear and nonlinear equations, stability theory, and qualitative behavior of solutions.

MATH 6315. Real Analysis II
3-0-3. Prerequisite: MATH 6317.
Such topics as structure of the real numbers, axiom of choice, Zorn's Lemma, Hamel basis, Baire category theorem, Stone-Weierstrass theorem, and the Daniell integral.

MATH 6317. Analysis I
4-0-4. Prerequisite: MATH 4313 or consent of School.
Lebesgue measure, measurable functions, Lebesgue integration, convergence theorems for integrable functions, signed measures, Hahn decomposition theorem, absolute continuity and differentiation, Radon-Nikodym theorem, Fubini's theorem.

MATH 6318. Analysis II
3-0-3. Prerequisite: MATH 6317 or consent of School.
L1 spaces, metric spaces, normed linear spaces, linear operators, Banach spaces, completeness, compact operators, spectral theory, spectral representations, weak convergence.

MATH 6320. Complex Analysis I
5-0-5. Prerequisites: MATH 4311, 4312, 4313, 4320.
Analytic functions, harmonic functions, conformal mapping, Cauchy's theorem, Cauchy's formulas for derivatives, maximum principle, power series, argument principle, residue theory, contour integration, analytic continuation, applications.

MATH 6325. Complex Analysis II
3-0-3. Prerequisite: MATH 6320.
Analytic continuation, product and partial fraction representation of meromorphic functions, Mittag-Leffler theorem, conformal mapping, Schwarz-Christoffel transformations, application to Dirichlet's Problem, normal families, Riemann mapping theorem.

MATH 6335. Functional Analysis II
3-0-3. Prerequisite: MATH 6318.
Elements of nonlinear functional analysis, fixed point theorems, locally convex linear topological spaces, Krein Milman theorem, spectral decomposition theorems, Banach algebras.

MATH 6341. Partial Differential Equations I
3-0-3. Prerequisites: MATH 4311, 4312, 4313, 4352.
Classification of partial differential equations, canonical forms, well posed problems, wave equation in R3, Huyen's principle, potential equation, heat equation, strong maximum principles, fundamental solutions.

MATH 6342. Partial Differential Equations II
3-0-3. Prerequisite: MATH 6341.
Elliptic equations, single and double layer potentials, Schwarz alternating procedure, subharmonic functions, weak solutions in a Sobolev space, regularity of weak solutions.

MATH 6343. Partial Differential Equations III
3-0-3. Prerequisite: MATH 6342.
Finite dimensional approximations, eigenvalues, eigen-functions, contraction mappings. Existence theory for evolution equations, semigroups, continuous choice of coordinates.

MATH 6341-2-3. Algebraic Topology I, II, III
3-0-3. Prerequisites: MATH 4431, 4101, and 4301 or consent of School.
Introduction to homological algebra, Cohomology and homotopy theories. Applications to fixed points of maps, spheres, invariance of domain, etc., homotopy, the fundamental group, covering spaces. Introduction to sheaf theory, category theory, spectral sequences.

3-0-3. Prerequisite: MATH 4431 or consent of School.
Introduction to topological spaces, regularity of weak solutions, double layer potentials, Schwarz alternating procedure, Huyen's principle, potential equation, heat equation, strong maximum principles, fundamental solutions.

MATH 6441. Calculus of Variations
3-0-3. Prerequisite: MATH 2309 or 3308 or consent of School.

MATH 6510. Methods of Applied Mathematics I
3-0-3. Prerequisite: MATH 2309 or 3308, and 3110 or consent of School.
The first of five courses providing access to mathematical methods important in science and engineering. Complex analysis. Credit not allowed toward graduate degrees in mathematics.

Text: none.

MATH 6511. Methods of Applied Mathematics II
3-0-3. Prerequisite: MATH 6501.
A continuation of MATH 6501. Partial differential equations and special functions. Credit not allowed toward graduate degrees in mathematics.

Text: none.

MATH 6510. Deterministic Models from the Physical Sciences and Technology
5-0-5. Prerequisites: PHYS 3121, MATH 4582.
Classical Fourier, Laplace, and Mellin transform techniques. Familiarity with partial differential equations and special functions. Credit not allowed toward graduate degrees in mathematics.

Text: none.

MATH 6581. Calculus of Variations
3-0-3. Prerequisites: MATH 4320, 4582, or consent of School.
The gamma function, Bessel functions, spherical harmonics, orthogonal polynomials, and other functions of particular interest in science and technology.

MATH 6586. Tensor Analysis
3-0-3. Prerequisites: MATH 3110 and 4583, or consent of School.
Tensor algebra, covariant differentiation, Cartesian tensors, curvilinear coordinates, introduction to differential forms.

Text: at the level of Sokolnikoff, *Tensor Analysis*.

MATH 6587. Field Theory with Applications
3-0-3. Prerequisites: MATH 4582, 4583, or consent of School.
Solution of field equations of mathematical physics by separation of variables in spherical, cylindrical, and other curvilinear coordinates with attention to advantageous choice of coordinates.

MATH 6640. Applied Computational Methods for Partial Differential Equations
5-0-5. Prerequisite: MATH 6267.
Knowledge of computer programming, familiarity with partial differential equations and elements of scientific computation.

Algorithms using the finite differences and finite elements for the numerical solution of steady and transient problems of engineering and science. Student computer use emphasized.

MATH 6643. Numerical Linear Algebra
3-0-3. Prerequisite: MATH 4301 or consent of School.
Numerical solutions of linear equations; least squares problems, the singular value decomposition and generalized inverse; methods for determining eigenvalues including the QR algorithm.

MATH 6645. Numerical Approximation Theory  3-0-3. Prerequisite: MATH 4311 or consent of School. Theoretical and computational aspects of polynomial, rational and spline approximation, including Chebyshev and least squares approximation, linear methods of approximation, B-splines, mesh selection.


MATH 6647. Theory of Numerical Methods for Partial Differential Equations  3-0-3. Prerequisites: MATH 4215 and MATH 2308. Stochastic process models for managerial contexts including production, congestion, cash flow, fisheries and passenger reservations. Processes include birth and death, renewal and Markov. Also listed as MSCI 6750.

MATH 7000. Master's Thesis

MATH 7121-2-3. Advanced Topics in Algebra I, II, III  3-0-3 each. Prerequisites: MATH 6121, 6122, 6123 or consent of School. Courses directed toward research in algebra. Areas of current research interests include homological algebra, finite groups, semi-groups, loop theory.

MATH 7241-2-3. Studies in Advanced Probability and Statistics I, II, III  3-0-3 each. Prerequisites: MATH 6241, 6242, 6243 or consent of School. Courses organized around recent broad advances in probability and statistics basic to research in these fields, content of courses varying from year to year. Typical courses would emphasize stochastic processes, ergodic theory, limit laws of probability, statistical decision theory, theories of estimation and hypothesis testing, etc.

MATH 7307-8-9. Advanced Problems in Ordinary Differential Equations I, II, III  3-0-3 each. Prerequisite: MATH 6307, 6308, 6309 or consent of School. Courses directed toward research in differential equations, the content varying from year to year. Representative topics include singular boundary-value problems, asymptotic solutions of differential equations, differential equations containing a large parameter, Poisson-Liapounov stability theory and differential equations in the large.

MATH 7311-2-3. Advanced Topics in Real Analysis I, II, III  3-0-3 each. Prerequisite: MATH 6317 or consent of School. Courses directed toward research in real analysis and related areas, the topics varying from year to year. Topics will be selected from areas as Hilbert space theory, theory of distributions, abstract harmonic analysis, ergodic theory, Denjoy and Perron integrals.

MATH 7321-2-3. Advanced Problems in Complex Variables I, II, III  3-0-3 each. Prerequisite: MATH 6320 or consent of School. Courses directed toward research in complex variables. Representative topics include topics from functions of several complex variables, conformal mapping.

MATH 7431-2-3. Advanced Topics in Mathematics I, II, III  3-0-3 each. Prerequisites: consent of School. Topics in a particular year may include some or all of variational techniques, asymptotic methods, differential operators of mathematical physics. Fourier transforms, nonlinear and singular integral equations.

MATH 7999. Preparation for Doctoral Examinations Credit to be arranged. Prerequisite: consent of adviser. Audit only.

MATH 8011-11-21-31-41-51. Special Topics in Math I, II, III  1-0-1. Prerequisites: consent of School. These courses are designed to provide students with experiences in areas not covered in the regular curriculum.

Department of Military Science

Established in 1917

Professor and Head—Colonel Richard D. Scharf, Assistant Professors—Majors Barringer F. Wingard, Napoleon Wright; Captains Richard G. Holcombe, Timothy Miller.

General Information

The purpose of the Army ROTC curriculum is to acquaint students with the Army, its role in our society, and the basic fundamentals of leadership and management. Concurrently, the overall program is designed to aid students in developing those abilities and attitudes which will make them academically successful and to develop well-educated junior officers for the Active Army, the Army National Guard, and the Army Reserve.

The curriculum is divided into two courses: a Basic Course open to all freshmen and sophomores and an Advanced Course for qualified juniors, seniors, and graduate students. The student who is undecided about pursuing a commission has the option of participating in the Basic Course without incurring a military obligation. Successful completion of the Basic Course (or commensurate training), a minimum 2.0 grade point average, and the appropriate medical and physical qualifications are prerequisites for enrollment in the Advanced Course. Successful completion of both courses and award of a bachelor's degree constitute the normal progression to gaining a commission as a Second Lieutenant. Courses are available to both men and women.

The overall Army ROTC curriculum prepares students to become effective leaders and managers in a variety of responsible and challenging commissioned officer fields, thus facilitating early middle management career development and progression. A description of the course requirements and associated programs is covered in the following paragraphs.

The Basic Course Curriculum

The basic program consists of a six-quarter block of instruction taken during the freshman and sophomore years. Successful completion of all six quarters satisfies the Military Science requirements for progression to the Advanced Course. These courses provide a foundation in basic military subjects such as customs and traditions, history, leadership, and map reading. They round out a student's academic life, provide a challenge, foster confidence, and facilitate personal growth and development. Courses are offered fall, winter, and spring quarters with two credit hours awarded for each course. Six of the hours earned may be applied as elective credits toward degree requirements at the school. Courses normally meet two hours a week plus a one-hour leadership laboratory. Students in the Basic Course do not incur any military obligation unless they are on an ROTC Scholarship. They are issued uniforms and may participate in the other ROTC related events and training such as Airborne School, Air Assault School, and Northern Warfare Training. The Basic Course consists of the following:

Course Credit Hours

MS 1021 The Army of Today (2-1-2) .................................................. 2
MS 1022 Army Operational Systems (2-1-2) .................................. 2
MS 1023 Basic Map Reading and Military Techniques (2-1-2) ...... 2
MS 2021 Introduction to Leadership (2-1-2) .................................... 2
MS 2022 Analysis of Command and Leadership(2-1-2) ................... 2
MS 2023 Military Training of the Individual (2-1-2) ...................... 2
Total .......................................................................................... 12

Optional Basic Camp

Those academically qualified students who are unable to fulfill the requirements of the Basic Program during their freshman and sophomore years may qualify for admission to the Advanced Course by successfully completing basic camp preparatory training.
This option is primarily designed to meet the needs of transfer students, those completing the sophomore year and others, including graduate students, who have six quarters remaining at the Institute. This option provides a two-year program in lieu of the standard four-year curriculum.

The basic camp option consists of a six-week training period conducted at an active Army post during the summer months. During 1985, six cycles will be available to meet student needs. Students desiring to exercise this option are required to submit a formal application and pass a general physical.

Students electing the basic camp training program will receive approximately $600 in addition to travel expenses to and from the camp. Uniforms, housing, medical care, and meals are furnished by the government during the camp. Interested students should contact the Military Science Department during the spring quarter, but not later than June 1.

**The Advanced Course Curriculum**

The Advanced Course is designed to develop fully a cadet's leadership and management potential, physical stamina, and self-confidence, as well as those personal characteristics desired in an Army Officer. The objective is to produce the highest caliber junior officer fully capable of discharging a wide spectrum of command and management responsibilities in the modern Army and in the business world.

The Advanced Course consists of six quarters of instruction normally taken during the junior and senior years. Successful completion of the six courses fulfills the Military Science academic requirements for award of an officer's commission. Eleven credit hours are earned of which nine may be applied as subsistence allowance of $100 a month, not to exceed $1,000 per academic year.

Service veterans, three- or four-year junior ROTC students, junior, or service academy cadets may qualify for direct entry into the Advanced Course. Entry is not automatic, and Department evaluation of previous training and academic achievement will determine appropriate placement level.

Advanced Course students are eligible to participate in the Simultaneous Membership Program with the Army Reserve and National Guard. Students in this program affiliate with an Army unit as an officer trainee, thus affording them the opportunity for enhanced leadership development. Students in this program receive an additional $90 per month.

Students enrolled in the Advanced Course are also required to complete a six-week Advanced Camp to become eligible for commissioning. Attendance at Advanced Camp normally occurs in the summer between the junior and senior years; however, it may be delayed as in the case of students in the Co-op Program. Students can also participate in additional voluntary training such as Airborne School, Ranger School, Cadet Flight Orientation Program, and Cadet Troop Leader Training. In addition to completing the Military Science academic requirements of both the Basic and Advanced Courses, the student must complete at least one undergraduate course from each of three designated fields of study: Written Communication, Human Behavior, and Military History. Completing one undergraduate course in Management and National Security Studies is strongly encouraged; ROTC Scholarship students are also required to take a foreign language course.

Students who successfully complete the Army ROTC curriculum and earn a bachelor's degree can be commissioned Second Lieutenants. Subsequent military service may be on active duty or with the Army Reserve or National Guard. Outstanding cadets who are selected as Distinguished Military students may gain Regular Army Commissions. The following courses constitute the Advanced Course:

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS 3011 Advanced Military Navigation (2-1-2)</td>
<td>2</td>
</tr>
<tr>
<td>MS 3012 Tactical Decision Making I (2-1-2)</td>
<td>2</td>
</tr>
<tr>
<td>MS 3023 Tactical Decision Making II (2-1-2)</td>
<td>2</td>
</tr>
<tr>
<td>MS 4011 The Military Team and the Junior Officer (2-1-2)</td>
<td>2</td>
</tr>
<tr>
<td>MS 4012 Military Management and Law (2-1-2)</td>
<td>2</td>
</tr>
<tr>
<td>MS 4023 Professional Ethics and the Army Officer (1-1-1)</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>11</td>
</tr>
</tbody>
</table>

**Scholarship Programs**

Each year the Army offers a variety of full scholarship programs to those young men and women who have demonstrated outstanding academic scholarship and leadership potential. Four-year scholarships are awarded incoming freshmen through national merit competition. Three-year and two-year scholarships are available on either a national competitive basis or directly through the professor of Military Science. Scholarships provide full tuition to both resident and out-of-state students, a stipend for textbooks and supplies, and laboratory fees in addition to a $100 a month tax-free allowance. Scholarship students will serve either on active duty or in the reserves.

**Options**

Qualified students entering their junior year of college may request that they be guaranteed a particular branch of the Army; requirements vary.

Students who desire entry into the Army aviation program may apply for Flight Orientation in their junior year.

Those students who wish to obtain a commission as an officer, but do not want to serve on active duty can request guaranteed reserve forces duty. In this program, students are guaranteed in writing that they will not be placed on active duty and can fulfill their entire commitment in the Army Reserve or National Guard.

The Department of Military Science allows both scholarship and non-scholarship students to participate in the Co-op Program. Co-op students are monitored and advised quarterly so that they meet requirements for commissioning.

**Student Advisory Services**

Faculty members are available throughout the academic year and during each summer orientation session in the Military Science Department to all students for academic counseling, schedule planning, and career guidance. Students and their parents are encouraged to seek advice on the overall Army ROTC program, scholarship opportunities, and officer career development. Appointments may be made personally or by collect call to (404) 894-4760/4761.

**Courses of Instruction**

MS 1500. Ranger Company (Optional) 1-1-1.

An organization designed to train and prepare the small unit leader with patrolling, military mountaineering, and stream crossing operations in a demanding physical environment. (Course is for audit only)
MS 1021. The Army of Today
2-1-2.
United States Army heritage, traditions, missions, and organizations as related to national defense, land warfare, and national objectives; includes the role of the Army officer in today's dynamic environment.

MS 1022. Army Operational Systems
2-1-2.
Continuation of topics introduced in MS 1021 with additional focus on current and future US Army Operational Systems.

MS 1023. Basic Map Reading and Military Techniques
2-1-2.
Basic Map Reading techniques with an introduction to various individual military skills required to perform as a member of a military organization.

MS 2012. Analysis of Command and Leadership
2-1-2.
Analysis and development of fundamental leadership skills required to lead individuals and small units in a military environment; includes use of case studies to develop organizational and leadership techniques.

MS 2021. Introduction to Leadership
2-1-2.
Introduction to fundamental leadership and management dimensions. Student applies in the areas of problem analysis and decision making; planning and organizing; delegation and control; and interpersonal communications.

MS 2023. Military Training of the Individual
2-1-2.
Introduction to military training management. Includes evaluating the training status of a unit, developing training objectives and standards, and planning and conducting military training.

MS 3011. Advanced Military Navigation
2-1-2. Prerequisite: Advanced Course standing or Department consent.
Military map reading, land navigation, and terrain analysis. Practical exercises require students to navigate cross country using terrain association and azimuths.

MS 3012. Tactical Decision Making I
2-1-2. Prerequisite: Advanced Course standing or Department consent.
Tactical Decision Making process within small military units. Includes introduction to squad and platoon level tactics with emphasis on troop leading procedures.

MS 3023. Tactical Decision Making II
2-1-2. Prerequisite: Advanced Course standing or Department consent.
Continued study and application of the decision making process at small unit level. Emphasis is placed on planning and executing tactical operations.

MS 4011. Military Team and the Junior Officer
2-1-2. Prerequisite: Advanced Course standing or Department consent.
A study of the broad principles, concepts, and operations of the combined arms team and its supporting elements from all branches of the services. Emphasis is placed on the role of the junior officer in today's Army. Practical exercises allow the student to plan, organize, and conduct military operations and activities in both a garrison and field environment.

MS 4012. Military Management and Law
2-1-2. Prerequisite: Advanced Course standing or Department consent.
Study of advanced management concepts and current management practices. Emphasis is placed on management of Army logistics, administration, and legal systems.

MS 4023. Professional Ethics and the Army Officer
1-1-1. Prerequisite: Advanced Course standing or Department consent.
The pressures and influence placed by contemporary society on the military officer. Includes the standards of conduct, integrity, and special trust which the military officer must function under.

Department of Modern Languages
Established in 1904
Professor and Head—Louis J. Zahn; Professor—George F. Walker (Adjunct); Associate Professors—J. Carroll Brooks, William W. Johnson, Edmun B. Richmond, Heidi M. Rockwood; Assistant Professors—Tatiana Gregory, Maria S. Venable, Roy O. Wyatt; Instructors—Linda L. Arthur, Janice H. Bos, Paula F. Finaudi, Fusan Ercan, Lynn F. Fedeli, Edith D. Fusillo, Gail Gershon, Maria E. Lewis, E. Helen McKinney, Odette P. Murphy, Agnes E. Robertson, Bette L. Harman-Cadena, Carol Saunders, Barbara K. Schulz, Larry J. Schulz, Athena Vachtsevanos, Charles E. Windish.

General Information
The diverse course offerings of the Department of Modern Languages provide students with opportunities for achieving reasonable fluency in writing, reading, speaking, and understanding several foreign languages including English as a foreign language. Further, they instruct students in the civilizations and literatures of the countries in which those languages are spoken.

Although the department does not offer a degree or "major," certificates or "minors" are available in French, German, linguistics, and Spanish. To receive a certificate in one of these options, students must take eighteen credit hours, fifteen of which must be on the 3000-level or above. Students should consult the department for additional details.

Students may take any courses for which they have the prerequisites as specified in the catalog descriptions. Counseling and placement examinations are available on request. Usually two years in high school equal one year at Tech. Each course is essentially a unit in itself, but beginning students are encouraged to pursue at least the elementary three-quarter sequence in order to achieve a minimum level of proficiency. Students must have departmental consent to enroll in or to take examinations for advanced standing in 1000-level courses after the successful completion of any 2000-, 3000-,or 4000-level course. Students who take courses in their native language must schedule courses no lower in number than 3001. Co-ops who are beginning a foreign language should limit themselves to French, German, and Spanish. Courses at the 2000, 3000, and 4000 level do not have to be taken in chronological order, provided prerequisites are fulfilled.

With minor exceptions, students can fulfill their thirty-six-hour humanities and social science requirements for graduation by taking courses, including linguistics courses, in the Department of Modern Languages. Students should consult the catalog course descriptions and the section of this catalog entitled "Humanities and Social Science Requirements" on page 40 in order to determine which courses are classified as humanities and which are classified as social sciences in their respective colleges. With the approval of their major schools, students may take any courses offered by the Department of Modern Languages on a pass/fail basis.

Engineering College students who choose to begin the study of a foreign language (1001-2-3) must take in addition at least three 3-hour courses 2000-level or higher, if they wish to receive "humanities" credit for the 1000-level courses; otherwise those 1000-level courses will count as "elective" credit. Engineering College students should note that the aforementioned provision does not apply to Linguistics; all Linguistics courses on the 1000 and 2000 levels carry "humanities" credit both individually and collectively.

College Credit for High School Study
The Department will grant nine hours of elective credit in French, German, Italian, Portuguese, and Spanish, or twelve hours in Russian for high school study in a foreign language, provided the student has two or more years of high school credit (or the equivalent) in the language in question and has completed nine quarter hours at the 2000, 3000, or 4000 level with an average grade of "C" or higher. Transfer students must complete at least three of the nine hours at Georgia Tech.

The department will not grant credit for high school study in a foreign language to students who speak the language in question as their native language or to students who have taken 1000-level courses or the equivalent at Georgia Tech or at other college-level institutions for which they have received transfer credit.

To have this free elective credit entered on their records, students must request that the appropriate form be submitted by the Department of Modern Languages to the registrar. This elective credit is not applicable toward fulfillment of the thirty-six-hour social sciences and humanities requirements for graduation. No grade is attached to this credit.

Doctoral Degree Language Requirements
See page 56.
All non-native speakers of English must fulfill requirements in English for graduation either by taking the same courses required of native speakers, offered by the Department of English, or by taking the special series (FL 1031-2-3) offered by the Department of Modern Languages.

Non-native speakers of English can fulfill the requirements of the Regents' Testing Program on competence in English by (1) taking the test administered to native speakers of English; by (2) passing the official Michigan Test of English Language Proficiency; or by (3) making at least a “B” on the final examination in FL 1033, LING 1001, 1002, or 1003.

The Department also serves the Institute by providing instruction in English as a foreign language, offered through non-credit programs in intensive English for foreign students (elementary, intermediate, and advanced levels) usually under the auspices of the Department of Continuing Education. The prerequisite is two years of high school English or the equivalent. Included in the program are grammar, pronunciation, sentence patterns, vocabulary building, spelling, reading, theme writing, and group and individual practice in the language laboratory. The Department offers these intensive courses of twenty hours per week during all four quarters. Pursuant to specific requests, the Department develops special programs to complement study in engineering and science.

For a descriptive folder write to Dr. Louis J. Zahn, Department of Modern Languages, Georgia Institute of Technology, Atlanta, Georgia 30332.

### Courses of Instruction

**English for Foreign Students**

All non-native speakers of English must fulfill requirements in English for graduation either by taking the same courses required of native speakers, offered by the Department of English, or by taking the special series (FL 1031-2-3) offered by the Department of Modern Languages.

Non-native speakers of English can fulfill the requirements of the Regents' Testing Program on competence in English by (1) taking the test administered to native speakers of English; by (2) passing the official Michigan Test of English Language Proficiency; or by (3) making at least a “B” on the final examination in FL 1033, LING 1001, 1002, or 1003.

The Department also serves the Institute by providing instruction in English as a foreign language, offered through non-credit programs in intensive English for foreign students (elementary, intermediate, and advanced levels) usually under the auspices of the Department of Continuing Education. The prerequisite is two years of high school English or the equivalent. Included in the program are grammar, pronunciation, sentence patterns, vocabulary building, spelling, reading, theme writing, and group and individual practice in the language laboratory. The Department offers these intensive courses of twenty hours per week during all four quarters. Pursuant to specific requests, the Department develops special programs to complement study in engineering and science.

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### Courses of Instruction

**Note:** (Hum.) = Humanities credit; (Hum.) = Social Science credit.

Students in the College of Engineering may include up to nine hours (twelve hours in Russian) of elementary foreign language study for humanities credit, provided nine additional hours are completed on the 2000 or higher levels; otherwise the 1000-level course will count as elective credit. This regulation does not apply to courses in linguistics.

**CHIN 1001. Introduction to Mandarin Chinese I**

3-2-4. Prerequisite: one-year college-level foreign language study or equivalent and consent of Department.

Intensive study of patterns of expression in spoken Chinese.

**CHIN 1002. Introduction to Mandarin Chinese II**

3-2-4. Prerequisite: CHIN 1001 or equivalent. Continuation of CHIN 1001, introduction to Chinese writing system.

**CHIN 1003. Introduction to Mandarin Chinese III**

3-2-4. Prerequisite: CHIN 1002 or equivalent. Continuation of 1002; more emphasis on written Chinese.

**CHIN 4901-2-3-4. Special Problems in Chinese**

Credit to be arranged.

**FREN 1011-12-13. Elementary Brazilian-Portuguese I, II, III**

3-0-3 each course. Prerequisites: 1011-none; 1012-1011 or equivalent; 1013-1012 or equivalent.


**FREN 1021-22-23. Elementary Italian I, II, III**

3-0-3 each course. Prerequisites: 1021-none; 1022-1021 or equivalent; 1023-1022 or equivalent.


**FREN 1031-2-3. English as a Foreign Language I, II, III**

5-0-5 each. Prerequisites: 1031 none; 1032, 1031 or equivalent; 1033, 1032 or equivalent.

May be taken by non-native speakers of English in lieu of ENGL 1001-2-3. Review of basic skills; 1031 stresses oral-aural skills and writing; 1032, writing, reading, vocabulary; 1033, composition, readings on life in the U.S.A. (Credit: 1031, 5 hours elective; 1032-3, 5 hours Hum. each.)

**FL 2011. Colonial Brazil and the Portuguese Empire, 1500-1808**

3-0-3. Prerequisite: FL 1013 or equivalent.

Cultural history of Portuguese America from conquest and settlement to the end of the colonial period. Includes grammar review. Conducted in Portuguese. (Soc. Sci.)

**FL 2012. Development of Independent Brazil, 1808-1930**

3-0-3. Prerequisite: FL 1013 or equivalent. Cultural history of Brazil from independence through the Empire and the Old Republic. Includes grammar review. Conducted in Portuguese. (Soc. Sci.)

**FL 2013. Brazil Since 1930: The Giant Emerges**

3-0-3. Prerequisite: FL 1013 or equivalent. Cultural history of contemporary Brazil from the rise of Vargas to the present day. Conducted in Portuguese. (Soc. Sci.)

**FL 2021. Cultural History of Florence 1300-1500**

3-0-3. Prerequisite: FL 1023 or equivalent.

Dante, Boccaccio, and the Medicis. Grammar review. Conducted in Italian. (Soc. Sci.)

**FL 2022. Cultural History of Rome 1500-1700**

3-0-3. Prerequisite: FL 1023 or equivalent.

Emphasis on Michelangelo, Bernini, Borromini. Grammar review. Conducted in Italian. (Soc. Sci.)

**FL 2023. Cultural History of Italy Since 1848**

3-0-3. Prerequisite: FL 1023 or equivalent.

Unification, Fascism, resistance, post-war boom, current unrest. Conducted in Italian. (Soc. Sci.)

**FL 3001-2-3-4. Special Topics in Modern Languages**

3-0-3. Prerequisite: consent of head of Department.

Permits students to do work in languages not treated in other courses and/or to engage in special research and/or experimental studies.

**FREN**

**FREN 1001. Elementary French I**

3-0-3. Prerequisite: none.

Essential principles of French grammar and phonetics, acquisition of vocabulary through simple conversational exercises and the reading of simple selections. (Hum.)

**FREN 1002. Elementary French II**

3-0-3. Prerequisite: FREN 1001 or equivalent. Continuation of FREN 1001, extension of the survey of French grammar, acquisition of a general vocabulary through conversation and reading. (Hum.)

**FREN 1003. Elementary French III**

3-0-3. Prerequisite: FREN 1002 or equivalent.

Reading of selected texts, composition, completion of the survey of French grammar. (Hum.)

**FREN 2001. Cultural History of France to 1610**

3-0-3. Prerequisite: FREN 1003, two years in high school or equivalent.

Development and evolution of social structures of France as reflected in literature, history, and art. Includes a review of grammar. Conducted in French. (Soc. Sci.)

**FREN 2002. Cultural History of France from 1610 to 1800**

3-0-3. Prerequisite: FREN 1003, two years in high school or equivalent.

Development and evolution of social structures of France from 1610 to 1800, as reflected in literature, history, and art. Continuation of a review of grammar. Conducted in French. (Soc. Sci.)

**FREN 2003. Cultural History of France Since 1800**

3-0-3. Prerequisite: FREN 1003, two years in high school or equivalent.

Development and evolution of social structures of France during the nineteenth and twentieth centuries as reflected in literature, history, and art. Concludes review of grammar. Conducted in French. (Soc. Sci.)

**FREN 2004-5-6. Drama Workshop I, II, III**

3-0-3 each. Prerequisite: FREN 2003 or equivalent. (Hum.)

**FREN 3007-8-9. Survey of Literature I, II, III**

3-0-3 each. Prerequisite: FREN 2003 or equivalent. (Hum.)

**FREN 3011. France Today I**

3-0-3. Prerequisite: FREN 2003 or equivalent.

Culture, history, and geography of modern France in lectures and class discussions, short papers on assigned topics; conducted in French. (Soc. Sci.)

**FREN 3012. France Today II**

3-0-3. Prerequisite: FREN 2003 or equivalent. Continuation of FREN 3011. (Soc. Sci.)

**FREN 3013. France Today III**

3-0-3. Prerequisite: FREN 2003 or equivalent. Continuation of FREN 3012. (Soc. Sci.)

**FREN 3021-2-3. Advanced Conversation I, II, III**

1-3-2 each. Prerequisite: 2003, 2023, or three years in high school or equivalent.

A conversational approach to topics of current interest in the social sciences in France. (Soc. Sci.)

**FREN 4001. French Stylistics**

3-0-3. Prerequisite: FREN 3003 or equivalent.

Advanced study of syntax and semantics, aimed at development of stylistic sensitivity. Compositions in French. (Hum.)

**FREN 4002. Classical French Literature**

3-0-3. Prerequisite: FREN 3003 or equivalent.

Survey of French classical literature, readings in Malherbe, Descartes, Pascal, La Rochefoucauld, La Fontaine, La Bruyere, Corneille, Moliere, and Racine. Lectures on the Classical Age; term report. Conducted in French. (Hum.)
FREN 4003. The French Novel
3-0-3. Prerequisite: FREN 3003 or equivalent.
Survey of the development of the French novel from the late seventeenth century through the twentieth century; term report. Conducted in French. (Hum.)
FREN 4901-2. Special Problems in French
Credit to be arranged.
Provides the special instruction required under special programs. (4901, Hum.) (4902, Soc. Sci.)

GERMAN
GER 1001. Elementary German I
3-0-3. Prerequisite: none.
Pronunciation, essential principles of German grammar, rapid acquisition of vocabulary by the reading of simple selections; elementary composition. (Hum.)
GER 1002. Elementary German II
3-0-3. Prerequisite: GER 1001 or equivalent.
Continuation of GER 1001. (Hum.)
GER 1003. Elementary German III
3-0-3. Prerequisite: GER 1002 or equivalent.
Reading and the acquisition of a large vocabulary; continued study of German grammar, composition. (Hum.)
GER 2001. Introduction to Modern German Culture I
3-0-3. Prerequisite: GER 1003 or equivalent.
Selected readings in German on the cultural, historical, and intellectual development of Germany. Class discussion of reading material. (Soc. Sci.)
GER 2002. Introduction to Modern German Culture II
3-0-3. Prerequisite: GER 1003 or equivalent.
Continuation of GER 2001. (Soc. Sci.)
GER 2003. Introduction to Modern German Culture III
3-0-3. Prerequisite: GER 1003 or equivalent.
Continuation of GER 2002. (Soc. Sci.)
GER 2051. Issues in Science and Technology I
3-0-3. Prerequisite: GER 2003 or equivalent.
Theoretical and practical approach to the study of English word and sentence formation using comparative data from different dialects and languages; grammar, punctuation, composition; readings in linguistics. (Hum.)
GER 2052. Issues in Science and Technology II
3-0-3. Prerequisite: GER 2003 or equivalent.
Continuation of GER 2051; treatment of additional topics—German family life, educational system, church and religion, development of the arts, the Hitler era. (Soc. Sci.)
GER 3013. Germany Today III
3-0-3. Prerequisite: GER 2003 or equivalent.
Continuation of GER 3011 and 3012; in-depth treatment of contemporary issues. Supplementary instructional media: slides, recordings, journals, and panel discussions. (Soc. Sci.)
GER 3031. The German Novelle I
3-0-3. Prerequisite: GER 2003 or equivalent.
GER 3032. The German Novelle II
3-0-3. Prerequisite: GER 2003 or equivalent.
Period: 1840-1885. Stifter, Keller, Storm, Eber-Eschenbach, Meyer. Conducted in German. (Hum.)
GER 3033. The German Novelle III
3-0-3. Prerequisite: GER 2003 or equivalent.
Period: 1885 to the present. Hofmannsthal, Mann, Kafka, Musil, Wiechert, Borchert, Gaiser, Piontek. Conducted in German. (Hum.)
GER 3041. German Radio Drama I
3-0-3. Prerequisite: GER 2003 or equivalent.
German radio drama as a literary genre. Study of works of representative dramatists. (Hum.)
GER 3042. German Radio Drama II
3-0-3. Prerequisite: GER 2003 or equivalent.
An in-depth study of the works of Gunter Eich. (Hum.)
GER 3051. The German Folksong
3-0-3. Prerequisite: GER 2003 or equivalent.

LINGUISTICS
The 1000-level courses are offered for foreign students who wish to perfect their English.
LING 1001. Fundamentals of English Linguistics I
3-0-3. Prerequisite: none.
English pronunciation contrasted with that of various foreign languages; vocabulary building; readings in linguistics. (Hum.)
LING 1002. Fundamentals of English Linguistics II
3-0-3. Prerequisite: none.
Theoretical and practical approach to the study of English word and sentence formation using comparative data from different dialects and languages; grammar, punctuation, composition; readings in linguistics. (Hum.)
LING 1003. Fundamentals of English Linguistics III
3-0-3. Prerequisite: none.
A theoretical and practical approach to English semantic structure and stylistic levels; composition; readings in linguistics. (Hum.)
LING 2001. Introduction to Language I
3-0-3. Prerequisite: none.
Study of the design of natural language with emphasis on the traditional description of its phonological and grammatical systems. (Hum.)
LING 2002. Introduction to Language II
3-0-3. Prerequisite: LING 2001 or consent of Department.
Introduction to modern grammatical and semantic theories of language. (Hum.)
LING 2003. Introduction to Language III
3-0-3. Prerequisite: LING 2002 or consent of Department.
Survey of the types of linguistic change and development, comparison of generic and genetic linguistic relationships, linguistic borrowing. (Hum.)
LING 3001. Introduction to Articulatory Phonetics
3-0-3. Prerequisite: LING 2003 or consent of Department.
Introduction to articulatory and acoustic phonetics, methodology for analyzing sounds in various languages, with emphasis on recording sounds in phonetic scripts and reproduction of sounds. (Hum.)
LING 3002. Introduction to Structural Linguistics I
3-0-3. Prerequisite: LING 3001 or consent of Department.
Methodology for phonological analysis of language, examination of phonological data from hypothetical and natural languages. Collateral readings, problems. (Hum.)
LING 3003. Introduction to Structural Linguistics II
3-0-3. Prerequisite: LING 3002 or consent of Department.
Continuation of LING 3002 with emphasis on morphology and syntax, study of the works of Bloomfield, Pike, and Harris. Collateral readings, problems. (Hum.)
LING 3004. Natural Language Processing
3-0-3. Prerequisite: none.
Primarily for ICS students; study of selected topics from grammar and semantics which are important in the understanding and processing of natural language in human and computer contexts. (Hum.)
LING 3005. Black English Linguistics
3-0-3. Prerequisite: LING 3001 or equivalent.
The origins and development of American Black English from the 1600s to the present. Includes analysis of its structure and its relationship to African languages and cultures. (Hum.)
LING 4001. History of Linguistics
3-0-3. Prerequisite: prior study of linguistics or consent of Department.
Survey of the theoretical developments in linguistic science with major emphasis on the developments of the nineteenth and early twentieth centuries. (Soc. Sci.)
LING 4002. Current Developments in Linguistics
3-0-3. Prerequisite: prior study of linguistics or consent of Department.
Live issues in the field and approaches favored by various contemporary schools. (Hum.)
LING 4003. Semantics and Linguistic Structure
3-0-3. Prerequisite: prior study of linguistics or consent of Department.
Various approaches to the problem of dealing with meaning in linguistic analysis. (Hum.)
LING 4021. Contrastive Language Systems 3-0-3. Prerequisite: LING 3001-2-3 or consent of Department. A comparison of the similarities and differences of selected major languages with English in respect to phonology, written representation, syntactic, and semantic categories.

LING 4075-6. Comparative Analysis of Major European Languages I, II, III 3-0-3 each. Prerequisite: LING 3001-2-3 or consent of Department. Emphasis on grammatical and semantic structure and their correspondences, English as the control language. LING 4075 treats the major Slavic languages. LING 4076 treats the major Germanic languages. LING 4077 treats the major Romance languages.

LING 4901-2. Special Problems in Linguistics Credit to be arranged. Provides the special instruction required under special programs. (4901, Hum.) (4902, Soc. Sci.)

PORTUGUESE See FL 1011 and 2011.

RUSSIAN

RUSS 1001. Elementary Russian I 3-2-4. Prerequisite: none. Pronunciation, essential principles of Russian grammar, acquisition of vocabulary through illustrative readings, intensive familiarization with recorded material. (Hum.)

RUSS 1002. Elementary Russian II 3-2-4. Prerequisite: RUSS 1001 or equivalent. Continuation of RUSS 1001, introduction of additional reading material as progress of class permits. (Hum.)

RUSS 1003. Elementary Russian III 3-2-4. Prerequisite: RUSS 1002 or equivalent. Continuation of RUSS 1002. Emphasis on the reading of simple prose. (Hum.)


RUSS 2003. History and Culture of Russia III 3-0-3. Prerequisite: RUSS 1003 or equivalent. Period: 1917 to the present. Review of grammar and oral practice. (Soc. Sci.)


RUSS 3002. Period: 1860-1900. The Golden Age of Russian Prose, Realism 3-0-3. Prerequisite: RUSS 2003 or equivalent. Readings in Russian. (Hum.)

RUSS 3003. Period: 1900 to the Present. Symbolism, Futurism, Soviet Literature 3-0-3. Prerequisite: RUSS 2003 or equivalent. Readings in Russian. (Hum.)

RUSS 4901-2. Special Problems in Russian Credit to be arranged. Provides the special instruction required under special programs. (4901, Hum.) (4902, Soc. Sci.)

SPANISH

SPAN 1001. Elementary Spanish I 3-0-3. Prerequisite: none. The beginning course. Pronunciation, grammar, reading, composition. Conversations with student assistants who are native speakers of Spanish. (Hum.)

SPAN 1002. Elementary Spanish II 3-0-3. Prerequisite: SPAN 1001 or equivalent. Continuation of SPAN 1001. (Hum.)

SPAN 1003. Elementary Spanish III 3-0-3. Prerequisite: SPAN 1002 or equivalent. Continuation of SPAN 1002. (Hum.)

SPAN 2011. Discovery and Conquest of the New World, 1492-1600 3-0-3. Prerequisite: SPAN 1003 or equivalent. The voyages of discovery and expeditions of conquest in sixteenth century Spanish America, with an introduction to the important Indian civilizations. Includes grammar review. Conducted in Spanish. (Soc. Sci.)

SPAN 2012. Colonial Spanish America and the Wars of Independence, 1600-1800 3-0-3. Prerequisite: SPAN 1003 or equivalent. Spanish America from the period of the vice-royalties and Caribbean pirates to the Wars of Independence in the 1800s. Includes grammar review. Conducted in Spanish. (Soc. Sci.)

SPAN 3001. Spanish-American Literature Before 1895 3-0-3. Prerequisite: SPAN 2013 or equivalent. Conducted in Spanish. (Hum.)

SPAN 3002. Spanish-American Literature Since 1895 3-0-3. Prerequisite: SPAN 2013 or equivalent. Conducted in Spanish. (Hum.)

SPAN 3003. Spanish Prose from 1700-1920 3-0-3. Prerequisite: SPAN 2013 or equivalent. Conducted in Spanish. (Hum.)

SPAN 3004. Cultural History of Mexico 3-0-3. Prerequisite: SPAN 2013 or equivalent. Readings from representative authors, Vocabulario building, lectures, discussions, conversation, and composition. (Soc. Sci.)

SPAN 3005. Contemporary Latin America 3-0-3. Prerequisite: SPAN 2013 or equivalent. Selected contemporary essays, speeches, and diverse documents reflecting social, economic, and political problems. Conducted in Spanish. (Soc. Sci.)

SPAN 3006. Grammar Review and Composition 3-0-3. Prerequisite: SPAN 2013 or equivalent. Advanced study of syntax and semantics, aimed at development of stylistic sensitivity. Compositions in Spanish. (Hum.)

SPAN 3007. Cultural History of Spain I 3-0-3. Prerequisite: SPAN 2013 or equivalent. History of Spanish civilization from prehistoric times to 1500. Conducted in Spanish. (Soc. Sci.)


SPAN 3009. Cultural History of Spain III 3-0-3. Prerequisite: SPAN 2013 or equivalent. Contemporary essays, speeches, and diverse documents reflecting social, economic, and political problems of this century. Conducted in Spanish. (Soc. Sci.)

SPAN 3011. The Short Story in Spain 3-0-3. Prerequisite: SPAN 2013 or equivalent. The short story in the literature of Spain from the Middle Ages to the twentieth century. Includes authors such as Cervantes, Valle-Inclan, Cela, and Mateu. (Hum.)

SPAN 3012. The Latin American Short Story 3-0-3. Prerequisite: SPAN 2013 or equivalent. The short story in Latin America both as a literary genre and as an instrument of social revolution, includes authors such as Echeverria, Dario, Lillo, and Borges. (Soc. Sci.)


SPAN 4008. Libro de buen amor 3-0-3. Prerequisite: SPAN 4007 or equivalent. Detailed historical, linguistic, and literary analysis of the Ruiz masterpiece as the vertex of Spanish medieval civilization. Conducted in Spanish. (Soc. Sci.)

SPAN 4009. Don Quixote, Part I 3-0-3. Prerequisite: SPAN 3006 or equivalent. Detailed historical study of Cervantes' masterpiece as the vertex of the Spanish literature, the prototype of the modern novel, and the essence of Renaissance and Baroque culture. Conducted in Spanish. (Soc. Sci.)

SPAN 4010. Don Quixote, Part II 3-0-3. Prerequisite: SPAN 3006 or equivalent. Continuation of SPAN 4009. (Soc. Sci.)

SPAN 4021. Spanish Drama before 1700 3-0-3. Prerequisite: SPAN 3006 or equivalent. Emphasis on Lope de Vega and Calderon. Conducted in Spanish. (Hum.)

SPAN 4022. Spanish Drama from 1700-1920 3-0-3. Prerequisite: SPAN 3006 or equivalent. Emphasis on Neo-classicism, romanticism, and the Generation of 1898. Conducted in Spanish. (Hum.)

SPAN 4023. Spanish Drama since 1920 3-0-3. Prerequisite: SPAN 3006 or equivalent. Emphasis on Garcia Lorca and Casana. Conducted in Spanish. (Hum.)

SPAN 4024. Spanish Prose before 1700 3-0-3. Prerequisite: SPAN 3006 or equivalent. Emphasis on the Celestina. Conducted in Spanish. (Hum.)

SPAN 4025. Spanish Prose from 1700-1920 3-0-3. Prerequisite: SPAN 3006 or equivalent. Emphasis on precursors and members of Generation of 1898. Conducted in Spanish. (Hum.)

SPAN 4026. Spanish Prose since 1920 3-0-3. Prerequisite: SPAN 3006 or equivalent. Emphasis on Spanish writers since the advent of the Franco regime. Conducted in Spanish. (Hum.)


SPAN 4032. Latin American Novel II 3-0-3. Prerequisite: SPAN 3003 or equivalent. The Latin American novel since World War II. Emphasis on social and literary aspect of novels of the "boom" period. Represented are such authors as Garcia Marquez, Vargas Llosa, Carpenter, and Fuentes. Conducted in Spanish. (Hum.)

SPAN 4091-2. Special Problems in Spanish Credit to be arranged. Prerequisite: consent of Department. Provides the special instruction required under special programs. (4091, Hum.) (4092, Soc. Sci.)

STUDY ABROAD

SA 4091-3. University System Study Abroad 5-0-5 each. The Study Abroad Program of the University System of Georgia. Up to fifteen quarter hours of credit for summer study abroad. (4091, Hum.) (4092-3, Soc. Sci.) Humanities and social science credit granted only once. For information on contents of various courses, contact the Study Abroad office at Georgia State University.
Department of Music
Department Head and Director of Choral Activities – Gregory Colson; Director of Bands – Bucky Johnson; Conductor of the Jazz Ensemble – Ronald Mendola.

General Information
Music activities at Georgia Tech center around three enthusiastic and well-known performing groups: Band, Chorale, and Jazz Ensemble. The Band meets three afternoons a week, the Chorale and Jazz Ensemble meet twice a week, and all three organizations give academic credit. The Department plans its activities with awareness of other demands upon Tech students so that a great amount of musical experience is concentrated into a limited time.

The Marching Band is known nationally as a result of its smart formations and dynamic sound in television performances at both bowl and regular season football games. Trips for out-of-town games provide an extra reward for members. As a change of pace, during the winter and spring quarters the Concert Band studies and performs a broader instrumental repertory with emphasis on basic theory, contrasting musical styles and periods, as well as baton technique of student conductors.

The Chorale, an eighty-voice singing group that combines the well-known men's glee club with the newer women's chorus, undertakes an ambitious series of classical, sacred, and popular-music performances on campus, in the Atlanta area, and in neighboring states on a spring-break tour. They are featured in concerts of sacred masterworks with members of the Atlanta Symphony and in Pops concerts with combos and the Jazz Ensemble. The thorough-going approach to music history, theory, and vocal technique allows Chorale members to earn academic credit. The Department plans its activities with awareness of other demands upon Tech students so that a great amount of musical experience is concentrated into a limited time.

The Jazz Ensemble, although new at Georgia Tech, has shown tremendous growth and has established a strong reputation through numerous local appearances. After meeting the prerequisite of a satisfactory audition, members are involved in rehearsals, lectures and discussions, listening sessions, and performances, resulting in a wide background of theory, history, and literature within the jazz idiom.

Courses of Instruction
MUSI 1102-3. Concert Band IA, IB
0-3-1. Prerequisite: consent of director. First course.

MUSI 1111. Marching Band I
0-2-1. Prerequisite: consent of director. First course.

MUSI 1200-2. Marching Band II
0-2-1. Prerequisite: consent of director. Second course.

MUSI 1201-2. Marching Band III
0-2-1. Prerequisite: consent of director. Third course.

MUSI 2102-3. Chorale – Mixed Singing Group IA, IB, IC
0-3-1. Prerequisite: consent of director. First course.

MUSI 2103-3. Chorale – Mixed Singing Group II, IIIB, IIIIC
0-3-1. Prerequisite: consent of director. Second course.

MUSI 2104-3. Summer Chorale – Mixed Singing Group ID
0-4-1.

MUSI 3102-3. Jazz Ensemble IA, IB, IC
0-3-1. Prerequisite: consent of director. First course.

MUSI 3103-3. Jazz Ensemble II, IIIB, IIIIC
0-3-1. Prerequisite: consent of director. Second course.

MUSI 3104-3. Summer Chorale – Mixed Singing Group IID
0-4-1.

MUSI 4102-3. Concert Band IA, IB
0-3-1. Prerequisite: consent of director. Fourth course.

MUSI 4103-3. Concert Band IB, IVB
0-3-1. Prerequisite: consent of director. Fourth course.

MUSI 4104-3. Marching Band IV
0-6-2. Prerequisite: consent of director. Fourth course.

MUSI 4301-2. Jazz Ensemble IVA, IVB, IVC
0-3-1. Prerequisite: consent of director. Fourth course.

MUSI 4302-3. Chorale – Mixed Singing Group IVA, IVB, IVC
0-3-1. Prerequisite: consent of director. Fourth course.

Department of Naval Science
Established in 1926
Commanding Officer and Professor of Naval Science – Captain Dennis Y. Sloan, USN; Associate Professor – Commander H. M. Lewandowski, USN; Assistant Professors – Major C. K. Curcio, USMC; Lieutenant Mark Johnson, USN; Lieutenant David Pilcher, USN; Lieutenant Archie Mitchell, USN; Lieutenant Martin Toher, USN; Lieutenant R. A. Hunt, USN.

General Information
The naval officer education program offers students the opportunity to qualify for service as a commissioned officer in the U.S. Navy or U.S. Marine Corps. The program consists of a standardized curriculum designed to complement and assist academic pursuits of imparting knowledge of the naval environment and fostering an understanding of the role of the Navy and Marine Corps in national security. Upon graduation, the student is commissioned and ordered to active duty involving flying, submarine warfare, or surface warfare, or to the Marine Corps.

Students in the program are enrolled in one of the three categories outlined below. The department conducts an orientation period for all new NROTC students during registration week prior to the fall quarter.

Scholarship Students
Scholarship students are appointed Midshipman, USNR, after nationwide competition. The Navy pays for their tuition, fees, and textbooks for a period of from four to five years. The government provides uniforms and subsistence allowance at the rate of $100 per month. At the end of one year, students must obligate themselves to complete the prescribed naval science curriculum, to make a cruise of from four to eight weeks each summer, to accept a commission as Ensign, USN, or Second Lieutenant, USMC, upon graduation, and to serve on active duty for four years after commissioning unless released earlier by the Navy Department. At the end of this period, their active duty obligation to the Navy or Marine Corps is fulfilled. If they do not desire to remain on active duty in the regular Navy or Marine Corps, they are ordered to inactive duty in the Navy or Marine Corps Reserve.

College Program Students
College program students are enrolled under the provision of Public Law 86-647. Students can enter the college program during the freshman year, or upon qualification, prior to April 1 of the sophomore year. Prior to starting the junior year, the college program student must enlist in the U. S. Naval Reserve for a period of eight years. The student must agree to serve on active duty for not less than three years after appointment to commissioned rank in the U.S. Naval Reserve or Marine Corps Reserve and to retain that commission until the sixth anniversary of receipt of the original commission.

College program students receive uniforms at government expense and during their junior and senior years receive subsistence allowance of $100 per month. They must complete the prescribed naval science curriculum, make a cruise of approximately six weeks during the summer after the junior year, and upon graduation accept a commission as Ensign, USNR, or Second Lieutenant, USMCR. If they desire, after receiving their reserve commission, college program students may apply for a commission in the regular Navy or Marine Corps.

Two-year Program
Sophomores may apply and compete nationally for two-year NROTC scholarships. The NROTC at Georgia Tech has no part in this
Selection although information and counseling are available. Those selected for either the Two-year College Program or Two-year NROTC Scholarship attend eight weeks of active duty training during the summer between the sophomore and junior years so that they can join their classmates on an equal footing in the junior year Naval Science classes.

Selection Procedures
Four-year Scholarship students are selected in nationwide competition based on SAT or ACT scores, high school performance, extracurricular activities, and interests. The selection process is administered by the Naval Recruiting Command; however, the NROTC unit will provide information and guidance.

The professor of naval science may nominate well-qualified college program students to the Chief of Naval Education and Training for scholarships ranging from one to three and one half years; academic performance at Georgia Tech is the primary selection criteria for these scholarships. Freshmen attending Georgia Tech or other Atlanta-area higher education institutions that have cross-enrollment agreements may apply for the College Program. Applicants may apply at the Naval Armory at any time; however, it is most desirable to apply during freshman orientation or early freshman year.

Curriculum
In addition to the required naval science courses, all Navy Option Scholarship Students must take calculus (MATH 1307-8 or MATH 1711-3) and physics (PHYS 2121 or 2141 series). All Marine Option students must take POL 3203 and POL 3204 or a substitute approved by the professor of naval science. Any additional requirements are based on whether the student is in a technical or non-technical major, Navy Option or Marine Option, and scholarship or non-scholarship. Each student must ascertain from the NROTC Department a complete description of program requirements since the above statement is only a general outline.

No more than six hours of credit in basic naval science courses and no more than nine hours of credit in advanced naval science courses will be applied toward a degree.

Courses of Instruction

Introduction to structure and principles of naval organization, terminology, customs and uniforms, missions of the Navy as they relate to sea power and maritime affairs.

Discussion of naval ship design and construction. Examination of concepts and calculations of ship stability characteristics. Introduction to shipboard damage control.

NS 1003. Naval Ship Systems II 2-1-2. Prerequisite: NS 1002.
Shipboard propulsion, electrical, and auxiliary engineering systems are examined. Nuclear propulsion, gas turbines, and other developments in naval engineering are presented.

NS 121. Seapower and Maritime Affairs 2-1-2.
The broad principles, concepts and elements of the topics with historic and modern applications to the United States and other nations.

A fundamental working knowledge of weapon system components and their contribution to the overall system is provided. The relationships of systems and subsystems are explored.

The broad principles, concepts and elements of the topics with historic and modern applications to the United States and other nations.

NS 2004-5. Amphibious Warfare I and II 3-2-3 each.
Two-quarter sequence designed to study projection of seapower ashore, emphasis on evolution of amphibious warfare in the 20th century. Strategic concepts, current doctrine discussed.

NS 401. Naval Leadership and Management I 3-1-3.
Survey of the development of managerial thought through functional, behavioral, and situational approaches. Managerial functions, communication, and major theories of leaders and motivation applied to the Navy organization. Accountability of the naval officer for the performance of both subordinate and technical systems is emphasized.

Discussion of the administrative duties and responsibilities of the junior naval officer for personnel management and division discipline. Includes study of significant features of Navy Regulations and Military Law and detail in the areas of enlisted performance evaluation, advancement, and service records.

Introduction to the Navy Human Resources Management Support System. The junior naval officer's duties and responsibilities for material maintenance and personnel training. Seminars in personal affairs planning, including finance, orders, benefits, travel, and related topics.

NS 401-2. Special Problems in Naval Science Credit to be arranged. Prerequisite: submission of a 500-word statement detailing the expected area of study to the professor of naval science and permission from the professor of naval science to enroll. Selected students pursue creative research in specialized areas of naval science under the supervision of a staff officer whose career specialty is in that field. Professional papers of publishable quality and depth will be sought. Students have the option of studying for one, two, or three credit hours per quarter and for one, two, or three quarters of the academic year.

Department of Physical Education and Recreation
Established in 1942

Department Head and Professor—James A. Reedy; Associate Professors—Bill D. Beavers, Phillip B. Sparling; Assistant Professors—Douglas L. Fowlkes, David W. House, Instructor—Patricia Tinklepaugh.

General Information
The Department of Physical Education and Recreation seeks to provide opportunities to develop new skills and gain information that will allow the student to lead a healthier and more productive life. Students who have completed their physical education requirement are encouraged to elect additional courses of interest.

The majority of activity and skills courses are scheduled on two alternate days per week, meeting two hours per day.

The Physical Education Requirement
All students entering Georgia Tech, unless medically disqualified, must satisfactorily complete the physical education requirement. The required courses, usually taken during the freshman year, are (1) PE 1060—Fitness: Theory, Evaluation and Conditioning or PE 1040—Health Education; (2) an aquatics course selected from PE 1010—Swimming, PE 1005—Beginning Swimming (exclusively for the nonswimmer), PE 2150—Advanced Lifesaving or PE 2160—Water Safety Instructor course; (3) a lifetime sport or activity selected from any of the remaining physical education courses.

The health information record will determine any medical exemptions from physical education courses. The Student Health Service must endorse all certificates of disability from personal physicians before the Department will accept them.

Students who are exempt for medical reasons from all physical education activity courses must satisfactorily complete PE 1040 (Health Education) and one hour free
elective to fulfill their physical education requirement. Students who are medically exempt from a single 1000-level course including swimming must substitute an additional 1000-level course in its place. The Department will grant credit to transfer students for comparable physical education courses completed at other institutions. Students who are twenty-five years of age or older upon matriculation to the Institute have the option of satisfying the physical education requirement for graduation by completing the regular physical education requirements or by satisfactorily completing PE 1040 and one hour free elective.

**Courses of Instruction**

Unless medically disqualified, all students will be required to complete three courses in physical education: (1) PE 1060 or PE 1040; (2) an aquatics course selected from PE 1010, PE 1005 (exclusively for non-swimmers), PE 2150, or PE 2160; (3) a lifetime sport or activity selected from any of the remaining physical education courses.

**PE 1005. Beginning Swimming**

0-4-1.

Introduction to swimming fundamentals and safety skills. Open exclusively to non-swimmers.

**PE 1010. Swimming**

0-4-1.

Each student strives for maximum safety by thoughtful experimentation with simulated water emergencies. Drowningproofing evolused as the basic method for survival.

**PE 1020. Beginning Gymnastics**

0-4-1.

Gymnastic movement is used to develop essential elements of fitness including flexibility, coordination, strength, balance, and kinesiathetic awareness. Open to both sexes.

**PE 1030. Women's Gymnastics**

0-4-1.

Instruction, demonstration, and practice of basic women's gymnastics skills utilizing the four Olympic women's events. Flexibility and general physical conditioning exercises are included.

**PE 1040. Health Education**

0-4-3.

Guest lecturers from the medical and allied health profession(s) acquaint the student with contemporary personal health concerns including drugs, nutrition, emotional health, and sex education.

**PE 1050. Aerobic Conditioning: Running**

0-4-1.

Primary emphasis on improvement of endurance and cardiovascular and respiratory system efficiency through an individually tailored program of jogging/running.

**PE 1060. Fitness: Theory, Evaluation, and Conditioning**

2-2-2.

Basic concepts on which lifetime fitness programs are founded. Role of exercise in health, weight control, and quality of life. Assessment of personal fitness and individualized exercise program for each student. Combination of lectures, laboratory demonstrations, and conditioning activities.

**PE 1070. Aerobic Dance**

0-4-1.

Improvement of flexibility, strength, and primarily cardiorespiratory endurance through basic dance exercises. Course components also include fitness assessment and weight control.

**PE 1090. Physical Conditioning: Strength Training**

0-4-1.

Instruction, demonstration, and practice of basic physical conditioning with emphasis on muscular strength. Activities include running, stretching, calisthenics, circuit training and weightlifting.

**PE 2020. Intermediate and Advanced Gymnastics**

0-4-1. Prerequisite: PE 1020 or 1030 or prior gymnastics experience.

Development of gymnastics skills beyond the beginning levels. Instruction in the ten international competitive events for men and women and acrobatics is included.

**PE 2050. Beginning Tennis**

0-4-1.

Designed for the beginning player. Introduction to fundamentals: ground strokes, basic serve, and volley. Rules and etiquette included.

**PE 2051. Intermediate Tennis**

0-4-1.

Concentration on intermediate skills, stroke refinement, spins, singles and doubles strategy.

**PE 2060. Volleyball**

0-4-1.

The serve, spiking, passing, team defensive and offensive play will be demonstrated and practiced after which team competition is organized.

**PE 2070. Racquetball**

0-4-1.

Singles and doubles competition follows basic fundamentals and offensive and defensive strategies.

**PE 2080. Bowling**

0-4-1.

Team and league bowling competition follows an instructional program utilizing both live and filmed demonstration of basic skills and techniques.

**PE 2110. Basketball**

0-4-1.

Instruction and practice in basic fundamentals followed by team competition.

**PE 2130. Soccer**

0-4-1.

Organization of teams and competition follows skills practice and demonstration of offensive and defensive strategy.

**PE 2150. Advanced Lifesaving**

0-4-1.

Instruction, demonstration, and practice of carries, approaches, and releases utilized in rescuing victims. Leads to Red Cross certification.

**PE 2160. Water Safety Instructor Course**

1-3-2. Prerequisite: current advanced lifesaving certificate and pass swimmer course skills.

Acquisition of motor skills and the mastery of methods of teaching lifesaving and swimming courses. Leads to Red Cross certification.

**PE 2170. Cardiopulmonary Resuscitation and Standard First Aid**

0-4-1.

Basic CPR and emergency first aid skills designed to lead student to Red Cross certification.

**PE 2180. Weight Control Through Diet and Exercise**

0-4-1.

Designed to assist individuals with weight reduction through modification of eating habits and activity patterns. The course promotes immediate and long term weight control.

**PE 3100. Exercise Physiology**

3-3-4. Prerequisites: junior standing and freshman natural science or consent of Department.

An introduction to the physiological effects of human physical activity. Topics include neuromuscular, cardiovascular-respiratory, and metabolic responses and adaptations to exercise.

This course is exempted from the six-hour limit on PE credit that may be counted toward graduation and may be used as a free or technical elective with the consent of the major department.

**PE 3801-2-3-4. Special Topics in Exercise Science**

Credit hours equal last digit of course number. Prerequisite: consent of instructor.

Current topics in exercise science are presented as demand or interest warrants.

**PE 3901-2-3-4. Special Problems in Exercise Science**

Credit to be arranged. Prerequisite: consent of laboratory faculty member.

Student projects conducted in the Exercise Science Laboratory under the direction of a faculty exercise physiologist. Exposure to research investigation including laboratory procedures and instrumentation.

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**School of Physics**

Established in 1939

Director and Professor—Edward W. Thomas; Assistant Director for Graduate Programs and Professor—Roger M. Wartell; Assistant Director for Undergraduate Programs and Associate Professor—Donald C. O'Shea; Regents' Professors—Charles H. Braden, Joseph Ford, Harold A. Gersch, Earl W. McDaniel, L. David Wylly (Emeritus); Professors—R. Martin Ahrens, Helmut Birizt. Christopher Bottcher (Adjunct), David Finkelstein, Martin R. Flannery, Ronald F. Fox, Ian R. Gatland, James L. Cole, Don S. Harmer, Uzi Landman, David W. Martin, Eugene T. Patronis, Jr., Augustus L. Stanford, James R. Stevenson, Jr., Henry S. Valk, Michael K. Wilkinson (Adjunct), J. Quitman Williams (Emeritus), R. A. Young; Associate Professors—Harry G. Dulaney, David B. Dusenberg, William G. Harter, James M. Tanner, Richard M. Williamson (Adjunct), William E. Woolf; Assistant Professors—Almet Erbl, David L. Fuller (Adjunct), David E. Grider, Rajarshi Roy, Peter A. Schulz; Principal Research Scientists—Christopher Summers; Senior Research Scientists—Fred L. Eisele, John L. Wood; Research Scientists II—Bobert N. Barnett, James R. Cagle, Charles L. Cleveland, Vincent Mallette, Martin W. Ribarsky.

**General Information**

Physics is primarily a basic science, and fundamental research into the principles of physics continues to occupy the attention of many physicists. The study of physics has also become increasingly important as a basis for fundamental research in interdisciplinary areas such as biophysics and chemical physics and as an applied science in government and industry. Furthermore, as society becomes more technically oriented, an education in physics may provide an advantageous pre-professional foundation.

The School of Physics offers basic science courses to freshmen and sophomores, some advanced service courses for students of
engineering, science, and mathematics, and advanced work leading to the bachelor's, master's, and doctoral degrees in physics. The School seeks to provide elective freedom in its undergraduate and graduate degree programs in order to enable students with a wide variety of interests to work out suitable programs of study.

In addition to offering courses in the fundamentals of physics, the School provides numerous specialized courses at the undergraduate and graduate levels, especially in areas related to the research interests of the faculty. Current faculty research interests include acoustics, atomic physics, computer science, elementary particles, general relativity, many-body theory, molecular physics, optics and laser physics, quantum logic, solid-state physics, statistical mechanics, physics instruction, and interdisciplinary areas in biophysics and materials science. Opportunities exist in these areas, as well as in some other areas by collaboration with faculty members of other departments, for undergraduate and graduate special problems, master's theses, and doctoral dissertations.

Information supplementary to this catalog that may be useful to students in the planning of programs of study is available from the School of Physics. A graduate brochure which further describes the opportunities for graduate study and research is available upon request. Students majoring in physics should consult frequently with their faculty advisers. Any student who does not have an adviser should contact the departmental office.

Undergraduate Programs

The School of Physics offers two undergraduate degrees, the Bachelor of Science in Physics and the Bachelor of Science in Applied Physics. The basis of the former degree program is the traditional preparation of a student for graduate study in physics. The degree program in applied physics may be better suited for entry into industry or government upon graduation, preparation for further professional training (medicine, law, dentistry, or business), or preparation for graduate study in some other discipline. The two degree programs differ in that a few courses intended primarily as preparation for graduate study in physics in the traditional program are replaced by courses oriented toward the applications of physics in the applied physics program. Greater flexibility in the choice of technical electives is available in the applied physics program.

Each of the baccalaureate programs contains the following: (a) courses needed to meet general institutional degree requirements; (b) a core of technical courses intended to give a strong background in mathematics and in the physical principles of mechanics, electricity and magnetism, thermodynamics, and the quantum theory which governs physical phenomena at the microscopic level of molecules, atoms, and nuclei; (c) technical electives which enable the student to explore areas of his or her choice in greater depth; and (d) free electives, about one-fifth of the total hours, which may be employed to schedule additional technical or nontechnical courses.

The considerable flexibility inherent in the physics curriculum is advantageous to students who wish to work out individual programs of study. At the same time, this flexibility suggests the need for consultation with advisers in order that good use may be made of the elective hours and in order to avoid scheduling difficulties that may arise in later quarters.

Since many students who earn a degree in physics have transferred from another discipline, the School has planned the degree programs to enable most students to transfer into physics with little or no loss of credit. A total of 190 credit hours and a grade point average of at least 2.0 in physics courses numbered 3000 and higher are requisites for the bachelor's degree in physics.

Certificate Programs in Physics

The School of Physics offers programs of study leading to certificates in Applied Optics and in Computer-based Instrumentation. The purpose of the programs is to prepare students for careers in industry where basic physical understanding is applied to the solution of technological problems. Course requirements, which are fulfilled in the junior and senior years, are detailed in brochures available from the School. The applied physics degree program is often used by students who seek certificates offered by the School of Geophysical Sciences. Details may be obtained from that school.

Bachelor of Science in Physics Curriculum

<table>
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<tr>
<th>Freshman Year</th>
<th>Course</th>
<th>1st Q.</th>
<th>2nd Q.</th>
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<tr>
<td>MATH 1307-8-9</td>
<td>Calculus I, II, III</td>
<td>5-0-5</td>
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<tr>
<td>CHEM 1101-2-3</td>
<td>General Chemistry</td>
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<tr>
<td>PHYS 2121-3</td>
<td>General Physics</td>
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<td>4-3-5</td>
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<td>Electives</td>
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Sophomore Year

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<td>MATH 2309-9</td>
<td>Differential Equations</td>
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Junior and Senior Years

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<tr>
<th>Course</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>PHYS 3121-2-3</td>
<td>Classical Mechanics and Electricity and Magnetism (5-0-5 each)</td>
</tr>
<tr>
<td>PHYS 3141</td>
<td>Thermal Physics</td>
</tr>
<tr>
<td>PHYS 3145</td>
<td>Quantum Mechanics I</td>
</tr>
<tr>
<td>Electives</td>
<td>Physics electives which must include at least three laboratory courses. These electives must be approved by the School of Physics and must not include more than six hours below the 3000 level</td>
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<tr>
<td>Electives</td>
<td>To bring total hours to 190</td>
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<tr>
<td>Total, junior and senior years</td>
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Footnotes are listed following the program for the Bachelor of Science in Applied Physics.

Bachelor of Science in Applied Physics Curriculum

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<td>Electives</td>
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<td>X-X-17</td>
<td>X-X-18</td>
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</table>
Use of Elective Hours

Students may utilize their elective freedom in the physics curricula to specialize in particular areas of physics, to prepare for careers in interdisciplinary areas of science, to compose a preprofessional program, or to gain a background in other technical or nontechnical disciplines. For assistance to students in planning programs of study with emphasis directed towards a particular objective, the School has formulated suggestions for the use of elective hours. Supplementary material, available from the departmental office or from faculty advisers, includes suggestions relevant to the following areas of study: graduate study in physics, acoustics, applied optics, biophysics, computational physics, computer-based instrumentation, geophysics, and solid-state physics. A candidate for either baccalaureate degree in physics needs not follow any one of these suggested areas of study but may combine features of several programs or devise individual programs of study.

Attention is also directed to the possibility of using elective hours for special problems (PHYS 3900-1-2 or 4900-1-2) conducted under the supervision of a faculty member.

Graduate Programs

Master's Programs

The School of Physics offers two master's degrees, the Master of Science in Physics and the Master of Science in Applied Physics.

The Master of Science in Physics is the traditional physics degree and normally comprises the program that a graduate student executes in the course of study towards a doctorate. Students may fulfill the requirements for the degree by taking forty-five hours of course work or by electing a master's thesis in lieu of fifteen hours of courses. Although there are no rigid course requirements for the degree, most students should include PHYS 6121, 6122, 6123, and 6141 and mathematics equivalent to MATH 4347-8 or MATH 6511-12-13. Students should also include a research component either through inclusion of Special Problems work or by election of a thesis.

The Master of Science in Applied Physics is intended to help prepare an individual for a career in industrial, independent, or government laboratories. It is a good choice for a terminal master's degree. However, the program may serve equally well as preparation for a doctoral program. The program includes a "practicum" of at least twelve credit hours in an area of applied physics. Examples of available areas include acoustics, instrumentation, optics, physical characterization of materials, and physics instruction. Students should take courses in the principles of physics of importance in applied physics (e.g., PHYS 4143, PHYS 6121, PHYS 6122, PHYS 4262, and mathematics equivalent to MATH 3110 and 4582), and additional courses in support of the practicum.

Doctoral Program

The Doctor of Philosophy degree is directed toward proficiency in independent scholarly work. The degree program comprises course work in the principles of physics, additional specialized courses both in the area of the doctoral thesis and in one or two other areas, demonstration of reading competence in a foreign language, the passing of a comprehensive examination, and an independent research investigation.

Fifteen credit hours must be earned in a minor field, which may be any approved technical or nontechnical field that the student chooses in consultation with his or her adviser. A minimum of ten graduate-level courses is strongly recommended. Completion of the seminar series, PHYS 8001-2-3, and four core courses, PHYS 6121-2-3 and 6141, is advisable prior to taking the comprehensive examination. Three depth courses from 7121-2-3 or 6142-3 are strongly urged, as well as fifteen hours of breadth courses from the remaining courses in the catalog. Mathematics equivalent to MATH 6511-2-3 is recommended for most doctoral candidates. A grade point average of 2.9 in courses taken while a graduate student is required to register for the comprehensive examination and is a requisite for the degree.

The School encourages students to commence participation in the departmental research programs early in their graduate careers. The undertaking of a doctoral thesis is reserved until the comprehensive examination is passed, which may occur during the second graduate year for a well-prepared student.

Courses of Instruction

PHYS 1000. Physics Orientation
1-0-1.

PHYS 1001. Survey of Great Advances in Modern Physics
1-0-1.

A series of lectures, each of which deals with an important area of physics research or application; e.g., superconductivity, lasers, nuclear structure and energy, transistors.

PHYS 2001. Physics of Space and Time
3-0-3. Prerequisite: PHYS 2121 or 2111.

PHYS 2021. Introduction to Astronomy I 3-0-3. The nature of behavior of the earth and the other members of the solar system will be examined. Text: at the level of Abell, Exploration of the Universe.

PHYS 2022. Introduction to Astronomy II 3-0-3. (PHYS 2021 is not a prerequisite for PHYS 2022.) The nature and behavior of the stars and galaxies will be examined. Text: at the level of Abell, Exploration of the Universe.

PHYS 2300. Physics of Music 3-0-3. A descriptive introduction to the physical principles of the various sources of musical tones, how the sounds are generated, transmitted, and received by the listener. Text: at the level of Rigden, Physics and the Sound of Music.

PHYS 2111-2-3. Elementary College Physics I, II, III 4-0-4 each. PHYS 2111 should be taken first; PHYS 2112 and 2113 may be taken in either order, but it is preferable that 2112 precede 2113. Credit not allowed for both 2111-2 and PHYS 2121-2-3 or (2141-2-3). This sequence of three courses treats the physical principles of mechanics; heat, wave motion, electricity, and magnetism; light and modern physics, respectively, for students in the less technical curricula. Method of teaching and subject matter are chosen to give an understanding of scientific methods and a background of scientific information needed to comprehend the commercial, cultural, and political significance of scientific progress.

Text: at the level of Hooper and Gwynne, Physics and the Physical Perspective.

PHYS 2121. Particle Dynamics 4-3-5. Corequisite: MATH 1309. Introduction to classical mechanics. Topics include kinematics, dynamics, energy, momentum, and rotational motion. Laboratory based on frictionless surfaces and stroboscopic photographic equipment emphasizes data analysis.

Text: at the level of Serway, Physics for Scientists and Engineers— with Modern Physics.

PHYS 2122. Electromagnetism 4-3-5. Prerequisite: PHYS 2121; corequisite: MATH 2307. Topics include electric field, potential, magnetic field, and electromagnetic induction. Calculus and vectors are used. The laboratory stresses use of electrical instruments including oscilloscopes.

Text: at the level of Serway, Physics for Scientists and Engineers— with Modern Physics.

PHYS 2123. Optics and Modern Physics 4-3-5. Prerequisites: PHYS 2122 and MATH 2307. Wave propagation, interference, diffraction, and polarization. Geometrical optics. Particle aspects of electromagnetic radiation and wave aspects of material particles. Bohr model. Laboratory illustrates wave propagation.

Text: at the level of Serway, Physics for Scientists and Engineers— with Modern Physics.

PHYS 2141-2-3. General Physics I, II, III 5-3-6 each. Prerequisites: see listings for PHYS 2121-2-3. This sequence parallels PHYS 2121-2-3; courses from the 2022 sequence may be intermixed. In this sequence some topics will be treated in more depth and some additional topics will be included. These courses are intended for students with demonstrated competence in mathematics who desire a more rigorous foundation in physics.

PHYS 2750. Physics of the Weather 3-0-3. An introductory treatment of the application of the basic physical laws to the understanding of weather phenomena. The main weather features will be descriptively developed and some elements of weather forecasting are analyzed. PHYS 2750 is the same as GEOS 2750.

Text: at the level of Battan, Fundamentals of Meteorology.

PHYS 2801-2-3-4-5. Special Topics 1-0-1 to 5-0-5 respectively. Courses in special topics of current interest in physics are presented from time to time.

PHYS 2900-1-2. Special Problems Credit to be arranged. Prerequisite: consent of School.

PHYS 3001. Introductory Modern Physics 5-0-5. Prerequisite: PHYS 2123. Survey of principles and phenomenology of modern physics, including atomic structure, nuclear phenomena, and the interaction of radiation with matter.

Text: at the level of Weidner and Sells, Elementary Modern Physics.

PHYS 3005. Principles of Energy 3-0-3. Prerequisite: PHYS 2113 or 2123. Applications of principles of mechanics, electricity and magnetism, thermodynamics, nuclear physics, and solid state physics to energy conversion processes, with emphasis on contemporary energy sources.


Text: at the level of Fowler, Nuclear Astrophysics.

PHYS 3121. Classical Mechanics 5-0-5. Prerequisite: PHYS 2123, MATH 2309 concurrent. Dynamics of particles including oscillations and planetary motion, rotation of rigid bodies, collisions.


PHYS 3122. Classical Electricity 5-0-5. Prerequisite: PHYS 2123, MATH 2309 concurrent. Electric and magnetic fields, potentials, resistance, inductance and capacitance, polarization, magnetic materials, development of Maxwell's equations.

Text: Cheng, Field and Wave Electromagnetics.

PHYS 3123. Classical Magnetism 5-0-5. Prerequisite: PHYS 3122. Applications of Maxwell's equations, including the propagation of electromagnetic waves; electrodynamics.

Text: Wangsness, Electromagnetic Fields.


Text: at the level of Callen, Thermodynamics.

PHYS 3143. Quantum Mechanics I 5-0-5. Prerequisite: PHYS 2121 and MATH 2309. Historical approach to wave mechanics. Operator, eigenfunction-eigenvalue problem solutions to Schroedinger's equation, free particle, particle in a box, the square well, harmonic oscillator, rigid roator and hydrogen atom.

Text: at the level of Eisberg, Fundamentals of Modern Physics.

PHYS 3211. Electromagnetics 5-6-7. Prerequisite: PHYS 2123. AC circuits; semiconductor devices; amplifiers, feedback, operational amplifiers, oscillators; introduction to digital circuits, combinational and sequential logic; representative experiments in the laboratory.

Text: Brophy, Basic Electronics for Scientists.

PHYS 3223. Geometrical Optics 3-0-3. Prerequisites: PHYS 2123 and MATH 2308. Development of optical analysis of lenses and reflectors using matrix theory. Coverage includes image formation, stops, aberrations, photometry, and analysis of typical optical systems.

Text: at the level of Blaker, Geometric Optics.

PHYS 3224. Optical Instruments Laboratory 1-3-2. Corequisite: PHYS 3223. Use of optical instruments for purposes of observation and measurement. Instrumentation includes spectrometers, interferometers, nodal slides, microscopes, and telescopes.


Text: at the level of Hecht and Zajac, Optics.

PHYS 3226. Advanced Optical Physics Laboratory 1-3-2. Corequisite: PHYS 3225. Optional laboratory taken with PHYS 3225. A small number of experiments designed to exemplify the material presented in lecture course.

PHYS 3230. Photographic Principles 2-3-3. Prerequisite: PHYS 2113 or 2123. Lectures and demonstration (laboratory) period. Relationship of photographic practice and scientific principles: photographic optics, photometry, perspective control, monochrome and color images and processing, image quality.

Text: at the level of Langford, Basic Photography and Advanced Photography.

PHYS 3241. Elementary Biophysics I 3-0-3. Prerequisite: PHYS 2123. Applications of the principles and techniques of the physical sciences to areas of the life sciences.

Text: at the level of Stanford, Foundations of Biophysics.


PHYS 3263. Computers in Physics 1-6-3. Prerequisites: ICS 1700 or equivalent, PHYS 2123. Computer solutions of realistic physics problems which use a variety of numerical techniques, including integration, solution of simultaneous algebraic equations, and solution of differential equations.

PHYS 3264. Computer Analysis of Physics Data 1-6-3. Prerequisite: PHYS 2123. Computer analysis and acquisition of experimental data from physics experiments, including an introduction to on-line experiment control.

PHYS 3265. Introduction to Acoustics 3-0-3. Prerequisite: PHYS 2112 or 2122. An introduction to the art and science of acoustics for students of varied backgrounds and interests. The

Curricula and Courses of Instruction
emphasis is on the basic physical mechanisms which underlie all acoustical phenomena.

PHYS 3751. Laser Physics
3-0-3. Prerequisite: PHYS 2123.
Principles of laser operations. Types of lasers. Survey lectures on the application of lasers to various fields. Course intended for both physics and nonphysics majors. PHYS 3751 is the same as EE 4751.

PHYS 3801-2. 3-4-5. Special Topics
1-0-1 to 5-0-5 respectively.
Courses in special topics of current interest in physics are presented from time to time.

PHYS 3900-1. 2. Special Problems
Credit to be arranged. Prerequisite: consent of School.

PHYS 4001. Development of Quantum Theory
5-0-5. Prerequisite: PHYS 3143 or equivalent.
An exposition of the historical development of quantum theory and an introduction to philosophical problems of quantum theory.

PHYS 4145. Quantum Mechanics II
5-0-5. Prerequisite: PHYS 3143 or equivalent.
Introduction to perturbation theory, identical particles, spin and semiclassical radiation theory. Applications to atomic physics.

PHYS 4146. Special Relativity
5-0-5. Prerequisite: PHYS 3122.

PHYS 4206. Interfacing Laboratory I
3-3-4. Prerequisite: PHYS 3211 or equivalent.
Introduction to interfacing theory, identical particles, spin and semiclassical radiation theory. Applications to atomic physics.

PHYS 4206. Interfacing Laboratory II
1-6-3. Prerequisite: PHYS 4206 or consent of School.
A continuation of PHYS 4206. Emphasis on individual student design and construction of interfaces for on-line control of experiments.

PHYS 4220. Optical Design
3-1-4. Prerequisite: PHYS 3223 or consent of School.
Principles of optical design, ray tracing and third order aberrations; laboratory stresses optical testing using conventional resolution tests and modulation transfer function.

PHYS 4221. Optical Fabrication
2-6-4. Prerequisite: PHYS 3223 or consent of School.
Theory and practice of vacuum deposition of metal and multi-layer thin films and of grinding and polishing optical elements.

PHYS 4229. Seminar in Contemporary Optics
1-0-1. Prerequisite: consent of School.
Recent developments in optics discussed orally and summarized in written reports.

PHYS 4251. Biophysics I
3-0-3. Prerequisites: PHYS 2123, BIOL 2211.
Application of thermodynamics and other physical principles to analysis of energy metabolism and membranes.

PHYS 4252. Biophysics II
3-0-3. Prerequisites: PHYS 2123, BIOL 2211 or equivalent.
A study of physical principles governing the conformations and interactions of biological molecules. Emphasis on the properties of nucleic acids and proteins and their interactions.

PHYS 4254. Biophysics-Biochemistry Laboratory
0-6-2. Prerequisite: PHYS 4251 or consent of School.
Selected experiments using biophysical and biochemical methods exemplifying studies on macromolecules and the principles of the techniques currently used in molecular biophysics and molecular biology. Offered jointly with BIOL 6040.

PHYS 4261. Atomic Physics
5-0-5. Prerequisite: PHYS 3143 or equivalent.

PHYS 4262. Solid State Physics
5-0-5. Prerequisite: PHYS 3143; PHYS 3143 or CHEM 2113.

PHYS 4263. Nuclear Physics
5-0-5. Prerequisite: PHYS 3143.
Basic properties of nuclei, interactions of radiation with matter, accelerators, radioactivity, nuclear reactions, nuclear models, elementary particles.

PHYS 4264. Plasma Physics
5-0-5. Prerequisite: PHYS 3122.
Basic properties of the plasma state via the Boltzmann equation, collisionless. Debye shielding length, diffusion, conductivity, oscillations, and propagation of EM waves.

PHYS 4755. Introductory Diffraction Studies
3-6-5. Prerequisite: senior standing in physics or consent of the School.
Introductory theory and practice of x-ray and neutron diffraction techniques, mostly powder, e.g. identification, lattice parameters, texture, line breadth, thermal neutron, and crystal orientation.

PHYS 4801-2. 3-4-5. Special Topics
1-0-1 to 5-0-5 respectively.
Courses in special topics of current interest in physics are presented from time to time.

PHYS 4900-1. 2. Special Problems
Credit to be arranged. Prerequisite: consent of School.

PHYS 6005. Computer Facilities for Graduate Research in Physics
1-6-3.
Introduction to the computational aspects of physics research and the characteristics of the computing systems available.

PHYS 6011. Principles of Nuclear Physics
4-0-4.
Radioactive decay and decay processes, interaction of radiation, statistical considerations in interactions, nuclear structure, stability and models, nuclear reactions and cross sections, properties of neutrons.

PHYS 6121. Theoretical Mechanics I
5-0-5.
Dynamics of particles and rigid bodies, including developments and applications of Lagrange's, Hamilton's and Euler's equations. Potential theory. Gyroscopic motion. Poison brackets, Hamilton-Jacobi theory.

PHYS 6122. Electrodynamics
5-0-5.
Discussion of Maxwell's equations, scalar and vector potentials, conservation laws, multiple moments and multiple radiation, dispersion.

PHYS 6123. Statistical Mechanics I
5-0-5. Corequisite: PHYS 6121.
Physical applications of probability theory. Classical and quantum statistical mechanics with numerous applications: ideal gas, imperfect gas, liquids, and solids.

PHYS 6132. Advanced Electricity and Magnetism
5-0-5.
A study of Maxwell's equations with applications to problems in electrical power systems, communications, signal processing, radiation, and electrical measurement.

PHYS 6141. Quantum Mechanics I
5-0-5. Prerequisite: PHYS 4143 or equivalent.
Nonrelativistic quantum mechanics. Representation of dynamical variables as operators or matrices, theory of angular momentum, perturbation theory, selected topics from radiation and scattering theory.

PHYS 6142. Quantum Mechanics II
5-0-5. Prerequisite: PHYS 6141.
Relativistic quantum mechanics, Dirac theory, the Lorentz group, antiparticles, relativistic Hamiltonians, propagators, Feynman graphs.

PHYS 6143. Quantum Mechanics III
5-0-5. Prerequisite: PHYS 6141.
A problem-solving course that applies principles of quantum mechanics to atomic, molecular, solid-state, and nuclear physics.

PHYS 6232. Solid State Physics I
5-0-5. Prerequisite: PHYS 4143 or equivalent.
Structural, electronic, and vibronic properties of solids; electron gas theory; collective excitations, electromagnetic properties; band structure; transport and thermal properties; semiconductors; defects.

PHYS 6233. Physical Crystallography
3-0-3. Prerequisite: PHYS 4755 or equivalent.
Experimental and analytical aspects of X-ray, neutron and electron diffraction crystallography applied to problems such as physical property mechanisms, defects and other topics of current physical interest.

PHYS 6251. Diatomic Molecules
3-0-3. Prerequisite: PHYS 4143 or equivalent.
Electronic structure, calculation of potential energy curves, absorption parameters, emission parameters, rotational line strengths, vibrational band strengths, calculation of Franck-Condon factors.
PHYS 6263. An Introduction to Collision Theory
3-0-3. Prerequisite: PHYS 4143 or equivalent.
Quantum theory of nonrelativistic elastic and inelastic scattering, rearrangement collisions, central, nonlocal, absorptive interactions, phase shift analysis, variational methods, semiclassical and impulse approximations, transition probabilities.

PHYS 6264. The Theory of Atomic Collisions
3-0-3.
Collisional excitation and ionization involving electrons, atoms, and molecules. Charge-transfer, recombination, ion-molecule reactions. Atomic processes in planetary atmospheres in astrophysics and in laboratory plasmas.

PHYS 6267. Atomic Collisions
3-0-3.
A discussion of the techniques by which atomic collisions phenomena are studied, includes scattering of ions and electrons in gases and scattering from solid surfaces.

PHYS 6300. Graduate Laboratory
1-6-3.
Students choose a program of several experiments from those available in varied fields such as nuclear physics, solid state physics, X-ray diffraction, optics and physics instrumentation.

PHYS 6310. Experimental Investigations in Physics
5-0-5.
Significant experiments from diverse areas of physics are discussed in terms of physical principles involved, critical design parameters, and interpretation of results.

PHYS 7000. Master's Thesis
5-0-5. Prerequisite: PHYS 6121.

PHYS 7121. Theoretical Mechanics II
5-0-5. Prerequisite: PHYS 6121.
Advanced topics in classical mechanics including Hamilton-Jacobi theory, action-angle variables, and canonical transformation theory. Introduction to modern theory of dynamical systems.

PHYS 7122. Electromagnetic Theory
5-0-5. Prerequisite: PHYS 6122.
Discussion of relativistic electrodynamics, radiating systems, multipole expansions, scattering, and diffraction. Exposure to magnetohydrodynamics and plasmas. Use of Lagrangian and Hamiltonian formulations.

PHYS 7123. Statistical Mechanics II
5-0-5. Prerequisite: PHYS 6123.
An advanced course in statistical mechanics, including problems of biological significance.

PHYS 7125. Introduction to Relativity
5-0-5. Prerequisites: PHYS 6121, 6122.
Reference frames and transformations, tensor calculus, review of special relativity, electrodynamics, the principle of equivalence, general relativity and gravitation, cosmologies and black holes.

PHYS 7126. Gravity
5-0-5. Prerequisite: PHYS 7125.

PHYS 7141. Quantum Mechanics of Many-Particle Systems
5-0-5. Prerequisite: PHYS 6141.
Interacting systems of particles described quantum mechanically using the method of second quantization. Application to Fermi and Bose systems.

PHYS 7143. Group Theory and Quantum Mechanics
5-0-5. Prerequisite: PHYS 6141 or equivalent.
Basic principles of group theory and the representation of groups by matrices. Applications will include atomic and molecular structure.

PHYS 7147. Quantum Field Theory
5-0-5. Prerequisites: PHYS 6141, 6122.

PHYS 7261. Optical Properties of Solids
3-0-3. Prerequisite: PHYS 6232.

PHYS 7263. Nuclear Physics
5-0-5. Prerequisite: PHYS 6141.
Use of nuclear models in computation of observable nuclear phenomena, including static and dynamic electromagnetic properties of nuclei.

PHYS 7265. Neutron Investigation of Condensed Matter
3-0-3. Prerequisite: PHYS 6141.
Time-dependent correlation functions and dynamic structure factors. Coherent and incoherent, elastic and inelastic scattering crossing sections. Applications to neutron scattering by photons, magnetic interactions, fluids.

PHYS 7999. Preparation for the Comprehensive Examination
Audit only.

PHYS 8001-2-3. Graduate Student Seminar
1-0-1.
Optional seminars. Representative research programs in the school are described by advanced graduate students, post-doctoral, and faculty members. The experimental basis of physics is illustrated through accounts of great experiments of importance to contemporary research.

PHYS 8101-2-3. Special Topics
1-0-1 to 5-0-5 respectively.
Courses in special topics of current interest in physics are presented from time to time.

Credit to be arranged.
Independent investigations, under the supervision of appropriate faculty members, in the area of condensed matter physics.

PHYS 8531-2-3. Special Problems in Acoustics
Credit to be arranged.
Independent investigations, under the supervision of appropriate faculty members, in the area of acoustics.

PHYS 8541-2-3. Special Problems in Applied Optics
Credit to be arranged.
Independent investigations, under the supervision of appropriate faculty members, in the area of applied optics.

PHYS 8551-2-3. Special Problems in Physics Instrumentation
Credit to be arranged.
Independent investigations, under the supervision of appropriate faculty members, in the instrumentation associated with experimental research in physics.

PHYS 8999. Preparation for Doctoral Dissertation
Audit only. Prerequisite: consent of School.

PHYS 9000. Doctoral Thesis

School of Psychology
Established in 1959


General Information
The School of Psychology serves a dual function in the Institute. First, it offers training in the basic and applied aspects of the science of behavior for the student majoring in architecture, engineering, management, and natural sciences. It also offers a program of study leading to the Bachelor of Science in Applied Psychology and the Master of Science and Doctor of Philosophy in Psychology.

The undergraduate curriculum in psychology stresses fundamentals, providing opportunity for broad training in mathematics, the natural sciences, humanities, social sciences, and management. The large number of elective courses enables the curriculum to fulfill a wide variety of educational and vocational needs. Students have been able to engage successfully in postgraduate study in many fields including business administration, history, industrial management, labor relations, law, medicine, music, psychology, and theology.

The program provides excellent preparation for graduate work in psychology and is especially adaptable to premedical education. Graduates of the program also have been employed successfully in a variety of positions relating to personnel subsystems (including human engineering), personnel research, personnel service, systems development, and the management and administration of business, engineering, and health programs.

Undergraduate Curriculum
The curriculum is technically oriented and stresses quantitative and experimental approaches to the study of behavior. Approximately 60 percent of the graduates of this curriculum have continued their studies in psychology graduate programs, medical and law schools, as well as in other graduate programs leading to degrees in such widely diverse fields as business, education, history, labor relations, marketing, music, and religion. Other graduates have been employed upon graduation in a variety of positions including general management, personnel research, personnel services (e.g. personnel training and employment), personnel subsystems (including human factors engineering), engineering psychology research, and systems engineering.

The curriculum lends itself to a special program intended to prepare students to teach behavioral science at the high school level. Through a cooperative arrangement with Georgia State University, interested
students may enroll for required education courses at that institution while working toward their bachelor's degree at Georgia Tech. Upon completion of the program, the student will be eligible to apply for a T-4 teaching certificate.

Certificate Program in Psychology

The School of Psychology offers for non-psychology majors five programs of study leading to certificates in biopsychology, engineering psychology, experimental psychology, industrial/organizational psychology, and social-personality psychology. Each program focuses upon a limited area of psychology that will be of interest and useful to students who wish to investigate the psychological complexities inherent in their major fields, or to those who simply wish to broaden their educations in a systematic manner.

Curriculum

Freshman Year

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Sophomore Year

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Graduate Curricula

Doctoral and master's candidates share a core curriculum of required courses that include three preseminars in general psychology, nine additional course hours in psychology to be prescribed by the student's faculty advisory committee with the approval of the director of the School of Psychology, and eighteen hours to be chosen by the student, with the approval of his or her advisory committee, from among courses in psychology and other fields. The School may grant permission to substitute another course for a required course if the student has passed a written examination. Doctoral candidates will complete all requirements for the master's degree, which includes writing a thesis and demonstrating proficiency in computer programming or a foreign language.

The School of Psychology views the master's degree as a significant educational achievement in itself and does not award it routinely for completion of part of the doctoral program. Master's programs prepare the student for continuation of graduate work toward the Ph.D. and/or for employment in business, industry, government, or education. Most students require two calendar years to complete the master's degree, which includes writing a thesis.

The doctoral program provides the student with an opportunity for advanced study in general-experimental, industrial-organizational, or engineering psychology. Each of these curricula consists of additional courses and programs of individual study and research beyond the core curriculum, which contribute to a strong background in general experimental psychology, quantitative methodology, and the student's area of specialization. The doctoral program will ordinarily require four years for students who enter immediately after obtaining the bachelor's degree.

Admission to graduate study in psychology with full graduate standing in the School of Psychology requires the equivalent of an undergraduate major in psychology or a related field with courses in general and experimental psychology, psychological statistics, testing and measurement, either industrial psychology or social psychology, and two quarters of calculus. Supplementary education in such areas as biology, chemistry, physics, engineering, foreign languages, and particularly mathematics is also advised. Students who have considerable undergraduate preparation in one or more of these areas may, with the approval of the School of Psychology, exempt some of the required psychology courses. All applicants should submit scores on the Miller Analogies Test and the Graduate Record Examination.

The psychology faculty encourages competent students in subjects other than psychology to apply for admission.

Courses of Instruction

PSY 3300. Psychology and Contemporary Issues in Society

3-0-3.

Contributions of psychology to an appreciation of selected contemporary issues. Topics may vary from quarter to quarter.

Curricula and Courses of Instruction

Psychology

262
PSY 3303. General Psychology I
3-0-3.
An intensive coverage of the methods and findings of contemporary psychology. Includes such topics as psychological development, learning, conditioning, and biological bases of behavior.

PSY 3304. General Psychology II
3-0-3. Prerequisite: PSY 3303.
A continuation of PSY 3303. Such topics as individual differences, perception, personality, and social psychology will be discussed.

PSY 4400. Developmental Psychology
3-0-3. Prerequisite: PSY 3303.
A comprehensive study of human behavior and psychological development from infancy through adolescence. Emphasis is placed on empirical and cross-species contributions.

PSY 4401. Industrial Psychology
3-0-3.
A survey of methods and findings in the scientific study of human behavior at work. Considered are such topics as selection, training, motivation, accidents, and environmental effects.

PSY 4402. Psychology of Adjustment
3-0-3. Prerequisite: PSY 3303.
Consideration of theories and etiology of typical and atypical human behavior. A principal objective is an increased understanding of self and others.

PSY 4403. Introduction to Psychological Testing
3-0-3. Prerequisite: PSY 3304 or 4401.
Consideration of the theoretical and practical issues in psychological measurement, with particular reference to psychological testing.

PSY 4404. Psychology of Advertising
3-0-3. Prerequisites: PSY 3304 or 4401.
An analysis of psychological principles and techniques which serve as a foundation for effective advertising. The scientific study of consumer behavior is emphasized.

PSY 4405. Seminar in Organizational Psychology
3-0-3. Prerequisite: PSY 4401 or 4410.
Study of psychological factors in organizational functioning, including theoretical and research issues.

PSY 4406. Psychological Statistics
2-2-3. Prerequisite: consent of School.
Application of statistical techniques to the design and analysis of psychological studies.

PSY 4407. Experimental Psychology I
2-3-3. Prerequisite: PSY 3303.
An introduction to psychological measurement and laboratory techniques used in the experimental study of topics such as sensory processes, perception, psychomotor performance and learning.

PSY 4409. Introduction to Engineering Psychology
3-0-3.
Engineering psychology is presented as an integral component in the design and evaluation of man/machine systems. Applied problems and general methodological questions are examined.

PSY 4410. Social Psychology
3-0-3. Prerequisite: PSY 3303.
Consideration of the behavior of the individual in relation to other individuals and groups.

PSY 4411. Experimental Psychology II
3-3-4. Prerequisites: PSY 3304, 4406, 4407 and consent of School.
Consideration of principles and research methods in the areas of learning and motivation with special emphasis on classical and operant conditioning of nonhuman animals.

PSY 4412. Psychology of Learning
3-3-4. Prerequisites: PSY 3304, 4406, 4407, and consent of School.
An empirical and theoretical analysis of human learning, memory and cognitive processes.

PSY 4413. Applied Experimental Psychology
3-3-4. Prerequisites: PSY 4404, 4412, and consent of School.
Consideration of the applications of the methods and data of experimental psychology.

PSY 4415. Physiological Psychology
3-0-3. Prerequisites: PSY 3304, BIOL 2211.
Neurophysiological, endocrinological, and biochemical basis of sensory and motor functioning, learning, memory, motivation, and behavior disorders.

PSY 4422. Comparative Psychology
2-2-3. Prerequisites: BIOL 2211, PSY 3304 and consent of School.
Consideration of principles and research methods of animal psychology and ethology. Literature reviews and reports, field trips and laboratory studies.

PSY 4423. Introduction to Psycholinguistics
3-0-3. Prerequisite: consent of School.
A critical examination of current psychological research and theory in language development and behavior.

PSY 4424. Introduction to Personality
3-0-3. Prerequisites: PSY 3304 or PSY 4410.
Introduction to and survey of major theories of personality.

PSY 4425. The Psychology of Aging
3-0-3. Prerequisites: senior or graduate standing. PSY 3303 and 3304 or equivalent.
Current research findings and their theoretical and practical implications will be discussed. Interactions between age and a variety of psychological processes will be discussed: perception, memory, learning, cognition, personality, psychomotor skill, and psychophysical processes.

PSY 4426. Behavioral Pharmacology
3-0-3. Prerequisites: BIOL 2211, PSY 3304, and consent of instructor.
An introduction to the study of drug-behavior interactions. Among the topics to be treated are the pharmacology of behaviorally active drugs, the influence of drugs on schedule-controlled behavior and stimulus control, the role of drugs as stimuli and the use of drugs for the analysis of behavior.

1-6-3 each. Prerequisites: anthropology, biology, or psychology background; demonstrated interest in animal behavior; consent of instructor.
This course takes place in Kenya, East Africa, and is limited to fifteen qualified students. Lectures by the instructor and resident scientists will provide the in-class portion of the course. Visits to national parks, game reserves, and lengthy in-field observation will introduce the students to the natural habitats of African animals.

PSY 4750. Social Psychology-Sociology Measurement Seminar
3-0-3. Prerequisite: PSY 4410 or equivalent and consent of School.
Problems, implications, and methodologies relating to the measurement of individual and group behavior in social situations. Students will receive supervised project experience. Also taught as SOC 4750.

PSY 4751. Psychology and Environmental Design I
3-3-4. Prerequisite: consent of School.
Introduction to psychological concepts relevant to environmental design. Survey of selected methods for assessing man-made environment. Taught jointly by psychology and architecture faculty. Cross-listed as ARCH 4751.

PSY 4752. Psychology and Environmental Design II
3-3-4. Prerequisites: PSY 4751 and consent of School.
Continuation of PSY 4751 with greater emphasis on independent research and development of design solutions to selected problems. Taught jointly by psychology and architecture faculty. Also taught as ARCH 4752.

PSY 4754. Models of Human Information Processing
3-0-3. Prerequisites: PSY 3303, 3304, ICS 1700, or equivalent.
General and unified approaches to psychological and computational modeling of human information processes. Emphasis on neural, sensory memory, semantic, and conceptual processing. Also listed as ICS 4754.

PSY 4755. Sex Roles: Their Development and Maintenance
3-0-3. Prerequisite: consent of instructor.
The role of drugs as stimuli and the use of drugs for the analysis of behavior.

PSY 4756. Human Factors in Software Development
3-0-3. Prerequisites: ICS 2400 or equivalent; PSY 3304.
Examination of human factors in the software design and application process from initial requirement and specification statements to coding, testing, implementation, and maintenance. Also taught as ICS 4756.

PSY 4800. Special Topics
1-3-2. Prerequisites: PSY 3304, 4407 and consent of School.
Guided independent study in an area of psychology not represented in departmental course offerings.

PSY 4802-3-4. Special Topics
2-0-2 through 4-0-4 respectively. Prerequisite: consent of School.
Special topics of current interest.

PSY 4814. Special Topics
3-0-3. Prerequisite: consent of School.
The student will, under the direction of a staff member, do semi-independent work in literature review and/or experimental design.

PSY 4815. Special Topics
3-3-4. Prerequisite: consent of School.
Students will work, under the direction of the instructor, on projects adding to their development beyond the scope of existing courses.

PSY 4900-1-2-3. Special Problems
Credit to be arranged. Prerequisite: consent of School.
Students engage in individual and group projects under the direction of a faculty member.

PSY 4953. Special Problems in Psychological Aspects of Environmental Design
Credit to be arranged. Prerequisites: PSY 4751, 4752, and consent of School.
Supervised individual study of problems relating to the interaction of environmental design and behavior.

PSY 6601. Advanced Industrial Psychology
3-0-3. Prerequisite: PSY 4401.
A survey of theoretical and pragmatic issues in industrial psychology. Recent developments and experimental findings will be discussed.

PSY 6602. Applied Experimental Psychology
3-0-3. Prerequisite: PSY 3304.
Consideration of the application of the methods and data of experimental psychology to the problems of man and the environment, emphasizing the engineering psychology approach.

PSY 6603. Social Psychology
3-0-3. Prerequisites: six hours of psychology and consent of School.
A study of principles of social learning, motivation and perception, and of attitudes and beliefs as they relate to behavior of individuals in groups.

PSY 6604. Human Information Processing
3-0-3. Prerequisite: consent of School.
A study of information processing theories and measurement techniques as applied to psychological problems, emphasizing human perceptual, communication, and learning processes.

PSY 6605. Proseminar in General Psychology I
3-0-3. Prerequisites: graduate standing and consent of School.
A comprehensive, advanced consideration of general psychology including such topics as conditioning, learning, memory, and cognitive processes.
PSY 6606. Proseminar in General Psychology I
3-0-3. Prerequisites: graduate standing and consent of School.

A comprehensive, advanced consideration of general psychology including such topics as psychological development, perception, and physiological psychology.

PSY 6607. Proseminar in General Psychology II
3-0-3. Prerequisites: PSY 6605, 6606 or equivalent and consent of School.

A continuation of PSY 6605 and 6606 involving consideration of such topics as personality, individual differences, and social psychology.

PSY 6608. Human Motivation
3-0-3. Prerequisites: graduate standing, PSY 6605 and consent of School.

Examines theoretical and pragmatic issues in the description and prediction of motivated behavior. Includes measurement problems, implications, and applications in a range of settings.

PSY 6609. Social Psychology of Organizations
3-0-3. Prerequisites: PSY 4410 or equivalent and consent of School.

Selected topics from social psychology which are of particular significance to an understanding of individual behavior in an organizational context. Supervised readings and discussion.

PSY 6610. Psychoacoustics
3-0-3. Prerequisites: PSY 3304 or equivalent and consent of School.

A comprehensive coverage of physiological and psychological acoustics, including analyses of auditory and extra-auditory response mechanisms and evaluation of research and theories in hearing.

PSY 6621-2. Foundations of Psychology I, II
3-0-3 each. Prerequisites: graduate standing and consent of School.

A sequence involving historical and current points of view in psychology, emphasizing issues important for psychological theory.

PSY 6624-5. Design of Psychological Experiments I, II
2-3-3 each. Prerequisites: graduate standing, MATH 3710, PSY 4406 or equivalent and consent of School.

A two-quarter sequence on the planning and implementation of research based on linear models, with reference to psychological consideration in data reduction and analysis.

PSY 6625. Experimental Methods in Psychology
2-3-3. Prerequisites: graduate standing, PSY 6605, 6606, 6623 or equivalent and consent of School.

Measuring the dependent variable in psychological experiments. Discussion is supplemented by practice in designing, conducting, and reporting experiments.

PSY 6626. Response Evaluation
3-0-3. Prerequisites: graduate standing, PSY 4406 or equivalent and consent of School.

Intensive consideration of theoretical and pragmatic problems in the description and evaluation of human responses in such areas as task analysis and performance measurement.

PSY 6627. Human Learning
3-0-3. Prerequisites: graduate standing, PSY 3303 or equivalent and consent of School.

A comprehensive consideration of principles, problems, methods, and experimental data in the study of human learning, including discussion of applications of theory and experimental findings.

PSY 6629. Psychomotor Skill Learning and Performance
3-0-3. Prerequisites: PSY 4406, 6605, 6606 or equivalent.

Human capabilities and limitations for learning and performing psychomotor skills are studied. Emphasis is on performance measurement and assessment of skill proficiency, prediction, and control.

PSY 6630. Psychometric Theory
3-0-3. Prerequisites: PSY 4403, 6624 or equivalent.

Preparation of students in statistical theory and techniques relevant to becoming professionally involved in construction, analysis, and evaluation of psychological and personnel tests.

PSY 6631. Personality and Social Development
3-0-3. Prerequisite: PSY 6607 or equivalent.

The developmental aspects of personality and socialization in children are examined. Particular attention will be given to empirically derived data, assessment techniques, and theoretical explanations.

PSY 6632. Perceptual Development
3-0-3. Prerequisite: PSY 6606 or equivalent.

Perceptual capabilities and experience are examined as they change across the life span. Special attention will be given to early development (infancy and childhood).

PSY 6680. Multivariate Analysis
5-0-5. Prerequisite: PSY 6624 or equivalent and consent of School.

Introduction to multivariate analysis in psychology with special emphasis on factor analysis.

PSY 6750. Human-Computer Interface
3-0-3. Prerequisite: permission of the School.

Human-computer interface is considered in terms of user-system compatibility. Concepts in human factors and interface design are covered in relation to capabilities and limitations of both humans and computers. Also taught as ICS 6750.

PSY 7000. Master's Thesis
1-3-2. Prerequisite: consent of School.

Preparation and discussion of papers on management issues involving psychological complexities. Jointly taught by members of the psychology and industrial management faculties.

PSY 7012. Seminar in Engineering Psychology
3-0-3. Prerequisites: PSY 6602, 6607 and consent of School.

Critical examination of current problems in a selected area of engineering psychology. The area to be discussed may vary each time the course is offered.

PSY 7020. Advanced Learning
3-0-3. Prerequisites: graduate standing, PSY 6605 or equivalent and consent of School.

An advanced and systematic examination of selected topics dealing with the experimental psychology of learning and memory. Theoretical approaches to learning, transfer and retention will be discussed.

PSY 7021. Sensation and Perception
4-0-4. Prerequisites: PSY 6606 or equivalent and consent of School.

An examination of human interpretation of physical stimulation. The student studies in some detail the nature of perceptual processes, including human sensory processes.

PSY 7022. Vision
3-0-3. Prerequisite: PSY 6606 or equivalent.

An advanced examination of the visual processes and the fundamental role they play in human behavior. Emphasis is placed upon objectively obtained data.

PSY 7023. Operant Conditioning
4-0-4. Prerequisite: PSY 6605 or equivalent.

Intensive treatment of methods, data, and problem areas of operant conditioning. Among the topics covered are response differentiation, schedules of reinforcement, and stimulus control.

PSY 7024. Primate Behavior
3-0-3. Prerequisites: graduate standing and consent of School.

A survey of research relating to primate behavior. A content course in which the major findings and theories of primate behavior will be considered; students will also discuss the methods employed in primate research, and observe selected species at the Yerkes Primate Research Center and Atlanta Zoological Park.

PSY 7050. Professional Problems
2-0-2. Prerequisite: graduate standing and consent of School.

Introduces the student to professional problems which he or she may face as a psychologist, including teaching, professional practice, and research. Ethical issues will be examined.

PSY 7051. Teaching Practicum
1-3-2. Prerequisite: PSY 7050.

Supervised college teaching for advanced graduate students in psychology. Discussion of teaching techniques, course and curriculum design in psychology, and student evaluation is included in the course. Students will prepare and present lectures on selected topics in psychology courses. Direct observation and television taping will be used as a basis for class discussions.

PSY 7750. Seminar on Psychology and Management
3-0-3. Prerequisites: PSY 6601, 6609, MGT 6150, or 6105 and consent of School.

Preparation and discussion of papers on management problems involving psychological complexities. Jointly taught by members of the psychology and industrial management faculties.

PSY 8504. Special Problems in Industrial Psychology
Credit to be arranged. Prerequisites: PSY 6601, 6602, or 6603.

Students will be expected to plan and execute a research problem involving investigation of some psychological aspect of management problems.

PSY 8505. Special Problems in Experimental Psychology
Credit to be arranged. Prerequisite: consent of School.

Students conduct research under direction of a faculty member on problems in the general area of experimental psychology.

PSY 9000. Doctoral Thesis

School of Social Sciences
Established in 1948

Director—Daniel S. Papp; Professors—Ronald H. Bayor, Patrick Kelly, Melvin Kranzberg (Callaway Professor of History of Science and Technology), Robert C. McMath, Jr., Daniel S. Papp, Frederick A. Rossini, Jay A. Weinstein; Associate Professors—James E. Brittain, Stanley R. Carpenter, Daryl E. Chubin, Lawrence Foster, August W. Giebelhaus, John H. Havick, Germaine M. Reed, J. David Roessner, Sandra W. Thornton, Dorothy C. Yance; Assistant Professors—Victoria Durant-Gonzalez, John N. Hines, Jon J. Johnston, John R. McIntyre, Gregory H. Nobles, David H. Ray.

General Information

The School of Social Sciences offers undergraduate course work in history, philosophy of science and technology, political science, and sociology as well as graduate courses
leading to an M.S. in Technology and Science Policy. Through this curriculum, the students gain an understanding of the complex issues that confront contemporary society. In addition, by comprehending certain aspects of societal and human relationships, students develop skills that enhance their professional expertise.

Certificate Programs in the Social Sciences
Seven certificate programs enable students to concentrate course work in areas of their particular interest. Each program provides for the systematic acquisition of ideas and opinions that enrich the students' understanding of the social dimensions and cultural roots of their professional majors. To aid students planning graduate studies in law, medicine, or business, the certificate programs also strengthen the students' backgrounds by allowing them to gain competence in areas additional to their majors.

Four of the seven certificate programs are in the traditional disciplines of history, philosophy, political science, and sociology. The remaining three programs cut across discipline lines to provide a foundation in international affairs, the interaction of science, technology and society, and urban studies.

Students interested in planning a certificate program in one of these areas should contact the School of Social Sciences for further information. A faculty adviser assists each student in planning a program of study to meet his or her needs and interests. The Social Sciences Office can provide detailed information concerning these programs.

U.S. and Georgia History and Constitution Requirements
The state of Georgia requires all students to display a knowledge of U.S. and Georgia constitutions and U.S. and Georgia history. To complete the requirements in U.S. and Georgia constitutions, a student must pass POL 1251 or 3200 or an examination on the U.S. and Georgia constitutions. To complete the requirements in U.S. and Georgia history, a student must either pass HIST 1001 or 1002 or pass an examination on U.S. and Georgia history.

The School administers examinations for both requirements each quarter (only to first quarter seniors). Students who do not take the exams or who are unsuccessful must then take the appropriate course(s) prior to graduation.

Graduate Program in Technology and Science Policy
The M.S. program in the rapidly expanding field of technology and science policy trains, in one to two years of study, professionals with technical and scientific backgrounds to identify and analyze policy issues emerging from technological and scientific development in contemporary societies. Graduates may anticipate professional employment by agencies involved in preparing technology assessments and environmental impact statements, formulating corporate responses to governmental policies affecting energy and the environment, evaluating the effects of governmental and corporate policies affecting technological innovation, and dealing with problems of transferring technologies to developing nations.

The program includes an intensive eighteen-hour multidisciplinary core involving theory and both quantitative and qualitative methodology. It also requires an elective concentration of at least fifteen hours, designed for the individual student's career needs, and a thesis. When possible, the thesis requirement will place the student in an internship environment similar to anticipated professional employment.

The team-taught core curriculum and the small number of students per faculty member will bring the student into early and intensive contact with faculty members. The program's flexibility in elective and thesis requirements allows the student an opportunity to arrange a custom-designed program.

Students applying for admission to the professional master's degree program must have earned a bachelor's degree from an accredited institution. Students should have a bachelor's degree or strong undergraduate concentration in engineering or science with experience in statistics. However, well-prepared students with other majors may also apply.

Courses of Instruction

HISTORY

HIST 1001. History of the United States to 1865 3-0-3.
A survey of the social, political, and economic history of the United States through the Civil War with emphasis on selected topics. Gives exemption from U.S. and Georgia history examination.

HIST 1002. History of the United States from 1865 to the Present 3-0-3.
A survey of the social, political, and economic history of the United States from the Civil War to the present with emphasis on selected topics. Gives exemption from U.S. and Georgia history examination.

HIST 1028. Introduction to the History of Science and Technology 3-0-3.
An introductory survey of the development of science and technology from antiquity to the present. Emphasis placed on sociocultural context and scientific and technological revolutions.

An examination of the social, economic and political currents of early modern Europe. Among the themes covered are social development and religious conflict, the emergence of a modern world economy, state centralization, and the advent of the scientific revolution.

HIST 3003. Nineteenth Century Europe 3-0-3.
This course traces the development of political ideologies, industrialization, labor activism, modern nation-building, and imperialism from the French Revolution to W.W.I.

HIST 3004. World Problems Since 1914 3-0-3.
Various twentieth century European themes to be examined in this course include the crisis of global war, communism, fascism, and the movement for European integration.

HIST 3012. History of Georgia 3-0-3.
Prerequisite: any one of HIST 1001, 1002, or history examination.

The problems which have confronted Georgia are examined in their historical setting. Relationship to the national scene gives perspective to the state's place in the nation.

HIST 3013. United States Colonial History 3-0-3.
Prerequisite: any one of HIST 1001, 1002, or history examination.

Settlement and growth of the English colonies in North America with emphasis on the foundation of American political and economic institutions.

HIST 3015. Survey of Sciences in the Sixteenth and Seventeenth Centuries 3-0-3.
An interpretative study of the scientific revolution including the social, economic and cultural context and origins of science in America.

HIST 3016. Survey of Sciences in the Eighteenth and Nineteenth Centuries 3-0-3.
The evolution of science and scientific institutions in Europe and the United States including rise of industrial research.

HIST 3017. History of the Old South to 1865 3-0-3.
Prerequisite: any one of HIST 1001, 1002, or history examination.

HIST 3018. History of the New South Since 1865 3-0-3.
Prerequisite: any one of HIST 1001, 1002, or history examination.

HIST 3020. American Diplomatic History 3-0-3.
Prerequisite: any one of HIST 1001, 1002, or history examination.

American diplomatic history since the Revolutionary War with emphasis on developments in the twentieth century.

HIST 3022. Afro-American History 3-0-3.
Prerequisite: any one of HIST 1001, 1002, or history examination.

Historical analysis of the black American from the ancient African beginnings to the present.

HIST 3024. The American Civil War 3-0-3.
Prerequisite: any one of HIST 1001, 1002, or history examination.

A survey with major emphasis on the military history of the war. Individual research is stressed.

Prerequisite: any one of HIST 1001, 1002, or history examination.

Special attention given to the rise of technology, our industrial system, the westward movement, development of our banking system, and government regulation of industry.

Focuses on the development of business institutions from the colonial period up to the present. Themes stressed include the role of the entrepreneur, the emergence of "big business," the evolution of new business structures, government-business relations, and business and society.
HIST 3027. History of Energy
3-0-3. Prerequisite: HIST 1001 or 1002.

The historical development of major energy sources, history of alternative energy technologies, and evolution of public policy in energy-related areas.

HIST 3028. United States Social and Intellectual History
3-0-3. Prerequisite: any one of HIST 1001, 1002, or history examination.

Studies in the social and intellectual traditions of the United States with an emphasis on the more recent period. Assigned readings.

HIST 3030. Technology and Economic Change
3-0-3.

Growth of technology in the modern world in its relationship to economic and social change.

HIST 3040. Recent Latin American History
3-0-3.

An examination of the roots of contemporary Latin American issues such as underdevelopment and modernization; nationalism and interregional integration; and social structures and institutions. Consists of a general overview and case studies.

HIST 3047-8-9. Technology in Western Civilization I, II, III
3-0-3 each.

The development of technology from the beginnings of man to the present, with emphasis upon interrelations between technology and society.

HIST 3786. The Immigrant Experience
3-0-3. Prerequisites: ENGL 1001-2.

The history and literature of immigrant/ethnic groups, such as English, Blacks, Irish, Germans, Asians, South ern and Eastern Europeans, Hispanics; exploring Old World reasons for emigrating, New World reactions, assimilation, bigotry, restrictive immigration policies, the Second World War relocation camp experience, alienation, the American Dream fulfilled. Lectures and papers. Jointly taught by English Department and School of Social Sciences.

HIST 4008. History of Technology in the United States
3-0-3. Prerequisite: any one of HIST 1001, 1002, or history examination.

A study of technology in America from the colonial period to the present including industrial and engineering history.

HIST 4016. History of Electrical Sciences and Technology
3-0-3.

The origins and evolution of electrical science, technology, and engineering. Emphasis placed on impact of major innovations in power, communications, and electronics.

HIST 4025. The United States Since 1917
3-0-3. Prerequisite: any one of HIST 1001, 1002, or history examination.

Social, political, economic, and diplomatic history of the United States in the middle of the twentieth century is examined as to causes, results, and movements.

HIST 4050. Twentieth Century Black History
3-0-3. Prerequisite: any one of HIST 1001, 1002, or history examination.

The inequities and achievements of the period are dealt with through an analysis of selected topics.

HIST 4075. The City in American History
3-0-3. Prerequisite: any one of HIST 1001, 1002, or history examination.

Selected topics concerning the social, economic, and political history of American cities with an emphasis on the role of technology in urban development.

HIST 4875-6-7. Special Topics in History
3-0-3.

HIST 4925-6-7-8. Special Problems in History
Credit to be arranged.

PHILOSOPHY OF SCIENCE AND TECHNOLOGY

PST 1126. Introduction to Philosophical Analysis
3-0-3.

An introduction to the nature of philosophy through critical study of selected works. The relation of philosophy to science, religion, and society will be emphasized.

PST 1127. Science, Technology, and Human Values
3-0-3.

An examination of the ways engineering technology shapes and is shaped by societal values. Also considers the appropriate and intermediate technology movements.

PST 3102. History of Ancient Philosophy
3-0-3.

A study of the development of philosophy from the early preSocratics’ scientific writings to Christian thought. The works of Plato and Aristotle stressed.

PST 3103. History of Modern Philosophy
3-0-3.

The development of Western thought from Bacon to Kant, with emphasis on the philosophical dimensions of the rise of modern science.

PST 3104. Contemporary Philosophy
3-0-3.

A study of the diverse movements in philosophy from Hegel to Russell with emphasis on the philosophical response to the development of modern scientific inquiry.

PST 3105. Types of Ethical Theory
3-0-3.

Critical examination of ethical theories, consideration of theoretical problems of ethics, nature and presuppositions of ethical judgments, justification and ethical standards.

PST 3107. Comparative Religions
3-0-3.

Introduction to the development of the most important concepts in modern religious systems. Emphasis will be placed on the contributions of philosophical analysis and theological debate.

PST 3113. Symbolic Logic
3-0-3.

An introduction to the symbolic analysis of logical argument. Includes propositional calculus, truth-tables, truth-trees and methods of deduction.

PST 4106. Philosophy of the Behavioral and Social Sciences
3-0-3. Prerequisite: senior standing or consent of the instructor.

Examination of philosophical views of social science, structural aspects of social science, relationship between natural and social science and other selected philosophical problems.

PST 4107. Philosophy of Technology
3-0-3. Prerequisite: PST 1126 or 1127 or consent of instructor.

A critical analysis of the methods, values, and underlying philosophy of technology. Examines theories of social change and the role played by technology.

PST 4110. Theories of Knowledge
3-0-3. Prerequisite: PST 1126 or 1127 or consent of instructor.

Critical examination of perception, verification, a priori and a posteriori knowledge, meaning and criteria of truth, presuppositions and cognitive significance of scientific and philosophical propositions.

PST 4115. Philosophy of Science
3-0-3. Prerequisite: PST 1126 or 1127 or consent of instructor.

Examination of selected problems such as causality, induction, scientific explanation, development of scientific knowledge, social and philosophical import of scientific theories.

PST 4120. Semantics
3-0-3. Normally taken by seniors.

The relations of formal logic and natural languages, sense and reference, semantical paradoxes, semantic criteria of truth.

PST 4757. Technology Assessment
3-0-3. Prerequisite: junior standing.

Systematic efforts to anticipate impacts on society that may occur when a technology is introduced, extended, or modified. Considers concepts, organization and uses of various specific assessment methods.

PST 4875-6-7. Special Topics in the Philosophy of Science and Technology
3-0-3. Topics to be selected.

PST 4944-5-6-7-8. Selected Problems in the History of Science
Credit to be arranged.

PST 4949. Special Problems
Credit to be arranged.

POLITICAL SCIENCE

POL 1251. Government of the United States
3-0-3.

Study of structure and function of governments of United States and Georgia. Gives exemption from United States and Georgia Constitution examination.

POL 1253. Comparative Political Systems
3-0-3.

Examination of current empirical political frameworks and conceptual vocabularies for purpose of developing common approach in analysis of individual political systems.

POL 2270. Introduction to Analysis of Political Behavior
3-0-3. Prerequisite: POL 1251 or consent of the Department.

Introduction to political analysis; behavioral and postbehavioral perspectives. Explores basic concepts employed in selected theoretical approaches.

POL 2271. American Political Thought
3-0-3. Prerequisite: POL 1251 or consent of the Department.

Examination and analysis of fundamental political ideas which have shaped the American political system.

POL 3200. American Constitutional Problems
3-0-3.

Study of structure and function of United States and Georgia government, taught largely through medium of constitutional law. Gives exemption from United States and Georgia Constitution examination.

POL 3203. National Defense Policy
3-0-3. Prerequisite: POL 1251 or consent of the Department.

Analysis of recent and current U.S. defense policy, including an examination of defense decision-making.

POL 3204. United States Military Policies
3-0-3. Prerequisite: POL 1251 or consent of the Department.

Examination of the armed forces’ relationship to society with particular emphasis on the development of the military-industrial complex.

POL 3205. American Foreign Policy
3-0-3. Prerequisite: POL 1251 or consent of the Department.

Study of formulation and implementation of U.S. foreign policy, stressing economic, political, and strategic factors.

POL 3210. National Legislative Processes
3-0-3. Prerequisite: POL 2270 or consent of the Department.

Empirical and systematic analysis of national legislative branch with attention to relationships among executive branch, interest groups, and Congress.
POL 3211. The American Presidency
3-0-3. Prerequisite: POL 1251, 2270 or consent of the Department.
Source, nature, and use of presidential power, the roles of the President. Recent historical examples emphasized.

POL 3215. Public Opinion
3-0-3. Prerequisite: POL 1251 or consent of the Department.
Public opinion polling techniques, including sampling, questionnaire construction, and interpretation. Analysis of actual opinion data collected on a national basis.

POL 3216. American Political Parties
3-0-3. Prerequisite: POL 1251 or consent of the Department.
Study of political party developments and their role in the electoral process.

POL 3217. State and Local Government
3-0-3. Prerequisite: POL 1251 or consent of the Department.
Analysis of structure and function of state, county, and municipal government.

POL 3220. Urban Government and Political Problems
3-0-3. Prerequisite: POL 1251 or consent of the Department.
An examination of political institutions and processes in the urban setting, including metropolitan government, and intergovernmental relations.

POL 3221. Urban Political Problems
3-0-3. Prerequisite: POL 1251 or consent of the Department.
A consideration of urban political behavior, including brokerage politics, politics in suburban, and community power structures.

POL 3222. Urban Public Policy
3-0-3. Prerequisite: POL 3220, 3221 or consent of the Department.
An empirical and systematic analysis of selected urban public policy areas, including such policy areas as education, housing, and crime control.

POL 3250. Public Administration and Public Policy
3-0-3. Prerequisite: POL 1251 or consent of the Department.
Study of decision-making and organization theory, bureaucratic policymaking, intergovernmental relations, taxing and spending policy.

POL 3265. Latin American Governments and Politics
3-0-3.
A survey of governmental and political processes in Latin American countries.

POL 3266. The Developing Nations
3-0-3.
A study of selected underdeveloped nations including economic and political development.

POL 3270. Western European Governments and Politics
3-0-3.
Comparative analysis of governmental and political processes in the nations of Western Europe.

POL 3275. Foundations of International Relations
3-0-3. Prerequisite: POL 1251 or consent of the Department.
An analysis of the theory and structure of the international system and their application to the contemporary international affairs.

POL 3280. Communist Political Systems
3-0-3.
An analysis of governmental and political processes in the communist governments.

POL 3281. Soviet Foreign Policy
3-0-3.
A study of the formulation and conduct of Soviet foreign policy. Consideration of ideological, geopolitical influences, development of relations with the Western world and the Third World.

POL 4200. Political Theory I
3-0-3.
A study of ancient, medieval, renaissance, and reformation political philosophy.

POL 4201. Political Theory II
3-0-3.
The development of political philosophy from the seventeenth century age of reason through the nineteenth century age of ideology.

POL 4202. Political Theory III
3-0-3.
An analysis of contemporary political philosophy, emphasizing radical ideologies.

POL 4205. Mass Communications and the Political Process
3-0-3. Prerequisite: POL 1251.
Examination of communications policies, the political process that shapes these policies, and the role of the mass media in the political process.

POL 4210. Science, Technology, and Public Policy
3-0-3. Prerequisite: POL 1251 or consent of the Department.
Examination of relationship between science and government including the effect of each area on the other in decision-making processes.

POL 4211. Science, Technology and World Politics
3-0-3.
An analysis of impact of science-technology on the international system: role of science and technology in foreign policy process.

POL 4212. Government Policy and Technological Innovation
3-0-3. Prerequisite: POL 1251 or equivalent, or consent of instructor.
Studies the relationship between government policy and the development and use of new technology in the private economy, and between technological innovation and economic growth.

POL 4250. Policy Analysis and Evaluation
3-0-3.
Study of the policy adviser in and out of government, social indicators and social accounting, evaluation of public policy, evaluation research techniques.

POL 4755. Sex Roles: Their Development and Cultural Influence
3-0-3.
Psychological principles, legal facts, and literary explications are integrated in an examination of the roles of men and women from three time perspectives: historical, current, and future. Also listed as ENGL 4755 and PSY 4755.

POL 4875-6-7. Special Topics in Political Science
3-0-3.

POL 4950, 4953-4-5-6. Special Problems in Political Science
Credit to be arranged.

POL 4951. Georgia Internship Program
Credit to be arranged (15 hours maximum).
Work-study program assigning student to project in state or local government. Student prepares research paper under jurisdiction of faculty member.

POL 4952. Legislative Intern Program
Credit to be arranged.
Service learning program combining an academic study of the legislative process with internship at Georgia Legislature in winter quarter. Interns selected competitively each year.

POL 6255. Governmental Aspects of Planning
3-0-3.
Analysis and study of problems and solutions in the field of city planning.

POL 6951. Governor's Intern Program
Credit to be arranged.
Directed reading and research for students to work as interns in departments of state government.

POL 6952. Legislative Intern Program
Credit to be arranged.
Service learning program combining an academic study of the legislative process with internship at Georgia Legislature in winter quarter. Interns selected competitively each year.

POL 8574. Special Problems in Political Science
Credit to be arranged.
Topics to be selected.

SOC 1376. Introduction to the Principles of Sociology
3-0-3.
A study of basic social relations, including social structure and functions, analysis of social processes, the foundations of personality, and analysis of social organization.

SOC 1377. Social Institutions
3-0-3.
An analysis of the structure and functions of social institutions, including familial, educational, religious, economic, and political. A study of institutional change and social disorganization.

SOC 1378. Social Problems in a Changing Society
3-0-3.
Some major social problems of modern society including crime, poverty, pollution, war, racism, and urban unrest.

SOC 1379. Introduction to Demography
3-0-3.
Factors affecting population problems, population growth, fertility, mortality, migration, distribution, and composition.

SOC 3306. Urbanization
3-0-3. Prerequisite: SOC 1376.
Growth of metropolitan communities, differentiation of functions, urban complexity, ecological areas, the city as a way of life, measures and trends in the process of urbanization.

SOC 3308. Statistics for Planning
3-0-3.
Statistical principles for analysis of economic, social, and population data, sampling, measures of central tendencies, normal curve, testing of findings, correlation and arriving at conclusions.

SOC 3330. Ethnic Minorities in American Society
3-0-3. Prerequisite: SOC 1376.
The principles of intergroup relations as they relate to the various racial and cultural groups in American society.

SOC 3334. Social Stratification and Mobility
3-0-3. Prerequisite: SOC 1376 or consent of the Department.
Process of stratification, including the criteria for and characteristics of stratification. Implications of stratification for the functioning of society.

SOC 3335. Social Problems of Industry
3-0-3. Prerequisite: SOC 1376 or consent of the Department.
A study of the nature of human relations in large-scale organizations, significance of authority, roles, communicative status and group norms in the work situation.

SOC 3338. Individual and Society
3-0-3. Prerequisite: SOC 1376 or consent of the Department.
A study of the nature of interpersonal relations in small groups and in large social settings, a consideration of the problem of alienations and anomie.

SOC 3339. Urban Sociology
3-0-3. Prerequisite: SOC 1376.
Introduces student to basic concepts of sociology as applied to urban phenomena, nature of urbanism, and consequences for social relations and human personality.
SOC 3340. Urban Ecology and Demography
3-0-3. Prerequisite: SOC 1376.
Involves application of ecological perspective to the study of urban phenomena, human spatial distribution theories of city location and patterns of city growth.

SOC 3501. Sociology of Science
3-0-3. Prerequisite: SOC 1376 or SOC 1377 or consent of instructor.
Introduction to Science and Technology as a social and cultural phenomenon. Topics include: the cultural contexts of the roles played by scientists and engineers in contemporary society and the institutional tensions between science and government.

SOC 3875-6-7. Special Topics in Anthropology
3-0-3.
SOC 4306. Technology and Society
3-0-3. Normally taken by seniors or graduate students.
Analysis of social conditions which promote or retard technological activity. Particular emphasis on the social role of the scientific and engineering professions in that development.

SOC 4308. Seminar in Contemporary Urban Sociology
3-0-3. Prerequisites: SOC 1376 and consent of the Department.
Extensive and critical review of literature in the field in order to keep students abreast of latest thinking concerning urban phenomena and problems.

SOC 4311. The Sociology of the Third World
3-0-3.
Principal focus on Third World countries as societies in development and thus affected by planning, technological innovation, and policy activity. Discussion of development issues at both the national and family levels.

SOC 4312. Seminar in Comparative Urban Development
3-0-3. Prerequisite: SOC 1376 and consent of the Department.
Entails cross-national comparison of cities and urban regions, appropriate models for understanding cities and urban regions, and strategies for handling problems.

SOC 4750. Social Psychology-Sociology Measurement Seminar
3-0-3. Prerequisite: PSY 4410 or equivalent and consent of the Department.
Problems, implications, and applications relating to the measurement of individual and group behavior in social situations. Students will receive supervised project experience.

SOC 4756. Technological Forecasting
3-0-3.
Emphasizes forecasting future trends and specific developments in areas of technology. Develops methodologies for identifying future functional capabilities and needs. Case histories in technological forecasting are utilized.

SOC 4875-6-7. Special Topics in Sociology
3-0-3. Topics to be selected.
SOC 4999. Special Problems in Sociology
Credit to be arranged.

TECHNOLOGY AND SCIENCE POLICY
TASP 6001. Technology, Science, and Society
3-0-3.
An intensive survey of the key issues in the relationship between technology and society. Technology and science are analyzed as knowledge systems and social institutions through an examination of major theoretical perspectives and cases.

TASP 6002. Policy Process and Analysis
3-0-3.
The major techniques and analytical approaches to the policy-making process at various levels of government and in the private sector.

TASP 6003. Selected Socio-Technical Policy Issues
3-0-3.
A comprehensive study of current socio-technical policy issues with emphasis on the writing of reports simulating those typically encountered in the field.

TASP 6011. Logic of Inquiry
3-0-3.
The first course in the methodology core sequence familiarizes the student with basic conceptual issues and techniques, and prepares one to design and evaluate research programs.

TASP 6012. Research Design and Data Analysis I
3-0-3. Prerequisites: TASP 6001 and ISYE 6739.
Focuses on communication of specific strategies and techniques for designing policy-relevant projects, data gathering, and statistical analysis.

TASP 6013. Data Analysis II and Forecasting
3-0-3. Prerequisite: TASP 6012.
A continuation of data analysis, considering the general linear model and topics in multivariate analysis. Emphasis on the techniques of social forecasting.

TASP 7000. Master's Thesis
1-0-0.
The first course in the methodology core sequence familiarizes the student with basic conceptual issues and techniques, and prepares one to design and evaluate research programs.

TASP 8121-2-3-4-5. Special Topics 1-0-1 through 3-0-5 respectively.

TASP 8545-6-7-8-9. Special Problems
Credit to be arranged.

Rules and Regulations

I. Purpose
These regulations are intended to set forth the requirements of the faculty to the end that a large student body may live and work together harmoniously with a minimum of friction and misunderstanding. Each student is expected to be a law-abiding citizen and to obey the laws of the City of Atlanta, Fulton County, the State of Georgia, and the United States.

II. Responsibility for Notices and Change of Address
A. Notices
All students will be required to have a box in the post office of the Georgia Institute of Technology which will be their official address, and they are expected to check this box each school day. Students are also expected to be aware of the contents of the general notices which appear in the Technique.

B. Change of Address
Students are responsible for reporting changes of residence with one week's time, to the Office of the Registrar.

C. Unclaimed Mail
Students are responsible for returning to the front window of the Post Office all mail in their post office boxes that is unclaimed after three days.

III. Attendance
A. General
1. Each quarter a course listing is published showing the time period for each class. Classes begin five minutes after the published starting time.
2. If an instructor should be late in meeting the class, the students shall wait twenty minutes after the published starting time. If the instructor has not arrived by that time, the students may leave unless specifically notified to await the instructor's arrival.

Student Rules and Regulations


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B. Class Attendance

1. There are no formal Institutional regulations regarding class attendance at the Georgia Institute of Technology. The resources of the Institute are provided for the intellectual growth and development of the students who attend. A schedule of courses is provided for the students and faculty to facilitate an orderly arrangement of the program of instruction. The fact that classes are scheduled is evidence that attendance is important; students should, therefore, maintain regular attendance if they are to attain maximum success in the pursuit of their studies.

2. All students are responsible for obtaining an understanding of each instructor's policy regarding absences; all students are expected to attend announced quizzes, laboratory periods, and final examinations. Although it is recognized that occasionally it may be necessary for students to be absent from scheduled classes or laboratories for personal reasons, students are responsible for all material covered in their absences, and they are responsible for the academic consequences of their absences. Work missed may be made up if the reasons for absences are acceptable to the instructors.

3. Students who are absent because of participation in approved Institute activities (such as field trips and athletic events) will be permitted to make up the work missed during their absences. Approval of such activities will be granted by the Student Academic and Financial Affairs Committee of the Academic Senate, and statements of the approved absence may be obtained from the Office of the Registrar.

IV. Grades and Scholastic Average

A. Grades

1. The letter grades for completed courses used in the calculation of scholastic average are the following: A—excellent (nine quality points) B—good (three quality points) C—satisfactory (two quality points) D—passing (one quality point) F—failure, must be repeated if in a required course (no quality points)

2. The following grades will be used in the cases indicated and will not be included in the calculation of scholastic average:

S—passing of a course taken under pass/fail or completion of a course in which no letter grade may be assigned;
U—failure of a course taken under pass/fail or unsatisfactory performance in a course for which no letter grade may be assigned;
V—assigned when the course has been audited; no credit given; implies no academic achievement on the part of the student and cannot serve as the basis for credit by examination at any future date.

3. The following grades will be used in the cases indicated:

I—incomplete. Assigned when a student is incomplete in some part of the course for reasons deemed satisfactory by the instructor or is absent from the final examination for reasons deemed satisfactory by the instructor. If the student's record is so poor as to preclude his/her passing, the instructor shall assign the grade of F or U. (Note: Registering and repeating a course in which an "I" grade has been assigned will not remove the outstanding "I" grade.)

W—out before the end of the fifth week. This symbol indicates that a student was permitted to withdraw without penalty. Withdrawals without penalty will not be permitted after the fifth week except in cases of hardship as determined by the registrar. Ordinarily, students who withdraw from school and receive all grades of W will not be permitted to reenroll the next succeeding quarter.

4. Final grades are reported to the registrar at the end of each term.

5. If a final course grade is believed to be in error, the student should contact the professor as soon as possible. In general, no change of grade will be made after the end of the student's next quarter in residence.

B. Scholastic Average

The scholastic average is calculated as the ratio of the total number of quality points earned to the total number of quarter credit hours in which a final letter grade has been assigned.

V. Scholastic Regulations

A. Classification of Students

1. Undergraduate students are the exception of non-degree seeking students shall be classified at the end of each quarter by the Office of the Registrar on the basis of the total number of quarter credit hours for which they have credit in accordance with the following schedule:

- Freshman: 0–45 credit hours
- Sophomore: 46–90 credit hours
- Junior: 91–136 credit hours
- Senior: 137+ credit hours

Students who have completed all requirements for a degree seeking student shall be classified at the end of each quarter. The scholastic average is unsatisfactory, or may be continued on academic probation.

2. The grade of I indicates that a student was permitted to withdraw without penalty.

3. The grade of D-passing (one quality point) is assigned for undergraduate students who receive D’s on their transcript. The grade of D-passing is assigned when the student is not on academic probation or drop, regardless of the student's previous record, if such action is deemed advisable.

4. Graduation grades will not be counted in the computation of point average. (Note: Certain majors, including undecided, may not be counted in the computation of point average.)

5. Academic probation is the scholastic average for the quarter of probation is below the minimum satisfactory scholarship requirement.

6. Undergraduate students whose scholastic average for any quarter is 0.0 or below may be referred to the Undergraduate Curriculum Committee, which may place the student on academic probation or drop, regardless of the student's previous record, if such action is deemed advisable.

7. A student who normally would be dropped from the student's permanent record and will count thereafter as an "F" on the student's permanent record and will count thereafter as an "F" in the computation of point average. (Note: Registering and repeating a course in which an "I" grade has been previously assigned will not remove the outstanding "I" grade.)

8. The scholastic standing regulations given above for graduate students do not preclude a school from having more rigorous requirements.

9. Part-time students

These regulations do not necessarily apply to students scheduling less than twelve credit hours.

b. The scholastic standing of these students may be determined by either the Undergraduate Curriculum Committee or the Graduate Committee, as appropriate, with the decision based on individual merit in each case.

D. Change of Major

1. Undergraduate students, by filing the required form, will be permitted one unrestricted transfer between majors (including undeclared) until they have accumulated credit for ninety hours. After ninety hours or upon subsequent request for transfer, the transfer will be permitted at the discretion of the school which the student is seeking to enter. (Note: Certain majors, because of high enrollment, have been granted a waiver of the one unrestricted transfer regulation. Students should consult the individual school concerning its current transfer policy.)

2. Graduate students, by filing the required form, may transfer with the concurrence of the schools involved and the Graduate Dean.

E. Exceptions

Exceptions to the scholastic regulations may be made by the Undergraduate Curriculum Committee or the Graduate Committee, as appropriate, whenever a consideration of the students complete record indicates that the application of a specific regulation will result in injustice.

VI. Deficiencies

A. General

1. A student who has received a grade of "I", "F", or "U" in a course has a deficiency in the course.

2. A student whose final grade is "F" or "U" has a failure in that course. He must repeat and pass the course in class before credit will be allowed. (See B.4.)

B. Removal of Deficiencies

1. An incomplete in a course must be removed and the grade changed to pass or fail not later than the end of the student's next quarter of residence.

2. The grade of "I" will not be counted in the computation of the student's point average at the end of the quarter in which the grade is received, nor in any quarter after, unless the student files the course for credit by examination at any future date.
3. A student who has a failure in a required course must schedule that course the next time it is offered while the student is in residence.

4. A degree candidate who has a single course deficiency for graduation will be permitted one reexamination not later than thirty-two hours before commencement exercises and thereafter one examination per annum until the deficiency is removed, with the dates of the annual periods beginning thirty calendar days after commencement exercises. This reexamination must be authorized by the registrar before being scheduled. The examination will be graded "S" or "U" and grade so recorded. The previously assigned "F" or "U" will remain a part of the record.

5. A degree candidate who has otherwise completed all requirements for graduation and who has an incomplete in laboratory work taken during his final quarter in residence may remove the incomplete at the convenience of the department of instruction concerned.

VII. Withdrawal From School
A. General
1. A student eighteen years of age or older may withdraw from school upon the submission of a formal resignation during the first five weeks of the quarter.

2. A student under eighteen years of age must include written permission from parents or guardian along with a formal resignation in order to withdraw from school before the official close of a quarter.

3. The proper forms for withdrawal are available from the Office of the Registrar. Students who withdraw without proper notification will receive grades of "F," "U," or "F" for the courses in which they were registered that quarter.

4. Permission and/or formal resignation are not required when a student has completed an official school quarter and does not register for the succeeding quarter. See Section VIII.A.3 for further information on withdrawal.

B. Readmission
See Section VIII for the regulations concerning readmission.

VIII. Readmission
A. General
1. A student who for any reason has remained out of school one or more quarters excluding the summer quarter must apply for readmission. This application, with all pertinent supporting information (except possibly another college transcript—see 2 below), must be submitted to the Registrar before the deadline for the quarter for which readmission is requested, as listed below:

- Fall – August 1
- Winter – December 1
- Spring – March 1
- Summer – June 1

Applications received after these deadlines will not be accepted.

2. Students who have attended other colleges should plan their readmission so as to allow ample time for official transcripts from those colleges to be sent to the Georgia Institute of Technology. If official transcripts have not been received prior to the last day of registration, the student seeking readmission will not be allowed to complete registration.

B. Readmission
1. A student who has been dropped once for unsatisfactory scholarship will ordinarily not be readmitted. A student who seeks an exception to this rule must have been out of the Institute for at least one quarter of the academic year and have had a conference with the major school concerning the readmission prior to the appropriate date listed in VIII.A.1 above. Because the summer quarter is not included in the academic year, students who are dropped at the end of the spring quarter will not be eligible for readmission until the beginning of the following winter quarter.

2. A student who has been dropped a second time for unsatisfactory scholarship will not be reenrolled in the Institute.

C. Transfer Credit
1. Course work pursued at another institution after dismissal from Georgia Tech for unsatisfactory scholarship may be considered as evidence for readmission.

2. If reenrolled, a student will not necessarily be given transfer credit for work taken at another institution after dismissal from Georgia Tech.

3. In no case will credit be awarded (except by examination) for courses completed at another institution that have previously been failed at Georgia Tech.

IX. Scheduling
A. General
1. Each student is strongly advised each quarter to schedule all prerequisite courses possible and should schedule all back courses before scheduling any advanced courses.

2. In dropping courses from their schedule, students must retain back courses in preference to advanced courses, unless permission to do otherwise is obtained from their school director.

3. The scheduling of back courses is the responsibility of the students, and they will be held accountable therefor.

4. Subject to approval by a faculty adviser, a course may be taken more than once for academic credit. All grades will count in determining the scholastic average, but the course will be counted only once for credit toward a degree.

5. See Sec. X for Institute rules for courses taken on a pass/fail basis.

B. Academic Load
1. The normal load scheduled by an undergraduate student in good standing should not exceed twenty-four credit hours. However, in exceptional cases, a total of twenty-three credit hours may be scheduled with the approval of the school.

2. Students who have attended other colleges should plan their readmission so as to allow ample time for official transcripts from those colleges to be sent to the Georgia Institute of Technology. If official transcripts have not been received prior to the last day of registration, the student seeking readmission will not be allowed to complete registration.

B. Readmission
1. A student who has been dropped once for unsatisfactory scholarship will ordinarily not be reenrolled. A student who seeks an exception to this rule must have been out of the Institute for at least one quarter of the academic year and have had a conference with the major school concerning the readmission prior to the appropriate date listed in VIII.A.1 above. Because the summer quarter is not included in the academic year, students who are dropped at the end of the spring quarter will not be eligible for readmission until the beginning of the following winter quarter.

2. A student who has been dropped a second time for unsatisfactory scholarship will not be reenrolled in the Institute.

C. Transfer Credit
1. Course work pursued at another institution after dismissal from Georgia Tech for unsatisfactory scholarship may be considered as evidence for readmission.

2. If reenrolled, a student will not necessarily be given transfer credit for work taken at another institution after dismissal from Georgia Tech.

3. In no case will credit be awarded (except by examination) for courses completed at another institution that have previously been failed at Georgia Tech.

B. Academic Load
1. The normal load scheduled by an undergraduate student in good standing should not exceed twenty-four credit hours. However, in exceptional cases, a total of twenty-three credit hours may be scheduled with the approval of the school.

2. Maximum credit hour loads are given in Sec. V.C.2, C.3, and C.4. Any hours above these limits must have prior approval of the Undergraduate Curriculum Committee or the Graduate Committee, as appropriate.

3. Graduate students must maintain a minimum of three credit hours each quarter of enrollment.

C. Auditing of Courses
1. Auditing of courses will be permitted to regularly enrolled students who have obtained the approval of their school and the departments concerned. Such courses count at full value in computing the student's load.

2. The grade for auditing is "V" (visitor), and this grade will have no effect on the student's grade point average.

3. No academic credit is granted for audit participation in a course.

4. Students are not permitted to change to and from an auditing status except through the regular procedures for schedule change or withdrawal.

X. Pass/Fail System
A. General
1. The option of the student's major school, credit toward a bachelor's degree may be allowed for courses taken under the pass/fail system and completed with a grade of "Pass."

2. The major school must approve all pass/fail courses included in the final program of study, and students should become aware of school requirements.

3. In graduate programs, thesis research hours will be evaluated on a pass/fail basis.

4. Pass/fail enrollment in any course may be restricted by the instructor offering the course.

5. Students who are permitted to register under the pass/fail system will be designated on the official class rosters; the grades recorded will be "S" for pass or "U" for failure. These grades will not be included in the calculation of the grade point average and cannot be changed to a grade which will count in the average.

6. Withdrawals from courses taken on a pass/fail basis will follow the same rules which govern withdrawals from courses included in the scholastic average.

B. Credit Hours Permitted
1. The maximum number of pass/fail hours permitted in an undergraduate program of study depends upon the number of credit hours that will be completed at Georgia Tech, as follows:

<table>
<thead>
<tr>
<th>Hours included</th>
<th>Hours allowed on pass/fail basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 to 89 credit hours</td>
<td>3 credit hours</td>
</tr>
<tr>
<td>90 to 124 credit hours</td>
<td>6 credit hours</td>
</tr>
<tr>
<td>135 to 179 credit hours</td>
<td>9 credit hours</td>
</tr>
<tr>
<td>180 or more credit hours</td>
<td>12 credit hours</td>
</tr>
</tbody>
</table>

2. For a second undergraduate degree, these limitations apply to the credit hours approved for the program of study for that second degree.

3. A master's degree program of study may include up to six course credit hours on a pass/fail basis.

XI. Joint Enrollment at Georgia State University
A. General
1. All examinations, examinations for advanced standing, and special examinations must be authorized by the registrar before being scheduled.

2. If the instructor considers it necessary during an examination, students may be required to present their student identification card to the instructor or an authorized representative.

B. Examinations for Advanced Standing
1. Students who offer satisfactory evidence that they are qualified to do so may receive credit for a course by examination. Such an examination is called an examination for advanced standing.

2. Examinations for advanced standing require the recommendation of the department of instruction in which the course is offered, payment of the appropriate fee, and authorization by the registrar.

3. Examinations for advanced standing will ordinarily be offered during the first five weeks of the quarter.

4. A student will not be allowed to take an examination for advanced standing in a given course more than twice.

5. An examination for advanced standing will be reported with an "S" or "U" grade. Neither grade will be included in the calculation of the scholastic average.

C. Final Examinations for Degree Candidates
A degree candidate will be exempted from examinations during final examination week in the quarter of graduation.

D. Regulations Covering Final Examinations
A student reporting to a final examination room more than fifteen minutes after the scheduled starting time shall not be allowed to take the examination unless a satisfactory explanation is presented to the instructor conducting the examination.
XIII. Undergraduate Degrees

A. General

1. To be considered for admission to candidacy for a degree, a student must have passed the Regents' Test and must make a formal petition for the degree during the quarter preceding the final quarter in residence. A petition for degree will not be accepted until the Regents' Test has been passed.

2. Students desiring to withdraw their name from the rolls of degree candidates must formally withdraw the petition for degree before the end of the eighth week of the quarter.

3. A degree program may include a maximum of six hours of basic ROTC and a maximum of nine hours of advanced ROTC.

4. The diploma of a candidate for a degree shall bear the date of the commencement at which the degree is awarded.

5. No student may be considered a candidate for a degree unless the final fifty credit hours required for the degree are earned in residence at Georgia Tech.

6. Work which was completed more than ten years prior to commencement must be validated by special examinations before it can be counted toward a degree.

B. Requirements for a Degree

1. To be a candidate for a degree, undergraduate students must have passed all courses required for the degree, must have a minimum scholastic average for their entire academic program of at least 2.0, and must have completed the physical education requirement for graduation with honor, the minimum scholastic average shall be 3.6. For graduation with high honor, the minimum scholastic average shall be 3.4. For graduation with honor, the minimum scholastic average shall be 3.2.

2. A student must have earned at least 100 credit hours at Georgia Tech to graduate with highest honor, with high honor, or with honor.

C. Graduation with Academic Distinction

1. A student enrolled for a second undergraduate degree shall be classified an undergraduate student.

2. To be a candidate for a second undergraduate degree, a student must have the recommendation of the director of the school concerned and the approval of the Undergraduate Curriculum Committee.

3. To obtain a second undergraduate degree, a student must complete all major required courses for the degree and earn credit for a total of at least fifty credit hours in excess of the requirement for any previous degrees earned.

4. All regulations in Section XIII A, B, and C apply to students completing second degrees.

XIV. Graduate Degrees

A. The Georgia law as amended March 4, 1953, requires that before graduation all students pass examinations or comparable courses in the United States and Georgia history as well as United States and Georgia Constitution.

B. Courses which may be substituted for the United States and Georgia Constitution and history examinations are listed in this catalog in the section for the Department of Social Sciences.

C. Regents' testing program.

All students completing requirements for baccalaureate degrees are required by the University System of Georgia to pass an examination designed to measure proficiency in reading and English composition. This examination is known as the Regents' Test. It must be passed before a petition for graduation will be accepted.

Student should obtain further information from the registrar.

5. Physical education requirement.

a. Unless medically disqualified, all students are required to complete the swimming course PE 1010 before graduation.

b. See Sec. XV for a complete description of the physical education requirements at Georgia Tech.

C. Graduation with Academic Distinction

1. For graduation with highest honor, the minimum scholastic average shall be 3.6. For graduation with high honor, the minimum scholastic average shall be 3.4. For graduation with honor, the minimum scholastic average shall be 3.2.

2. A student must have earned at least 100 credit hours at Georgia Tech to graduate with highest honor, with high honor, or with honor.

D. Second Undergraduate Degree

1. A student enrolled for a second undergraduate degree shall be classified an undergraduate student.

2. To be a candidate for a second undergraduate degree, a student must have the recommendation of the director of the school concerned and the approval of the Undergraduate Curriculum Committee.

3. To obtain a second undergraduate degree, a student must complete all major required courses for the degree and earn credit for a total of at least fifty credit hours in excess of the requirement for any previous degrees earned.

4. All regulations in Section XIII A, B, and C apply to students completing second degrees.

XV. Physical Education

A. General

1. All students entering Georgia Tech as freshmen are required to complete satisfactorily four credit hours in physical education courses. (For a complete description of the physical education requirements at Georgia Tech, refer to the Department of Physical Education and Recreation listed under the College of Sciences and Liberal Studies in the "Curricula and Courses of Instruction" section of this catalog.)

2. Transfer students will be granted credit for comparable physical education courses completed at other institutions.

3. Students who are twenty-five years of age or older upon matriculation to the Institute have the option of satisfying the physical education requirement for graduation by completing the regular physical education requirements or by completing PE 1040 and one hour of free electives.

B. Medical Exemptions

1. The Health Information Record on file with the Director of Health will be used to determine any medical exemptions from physical education courses. All certificates of disability from personal physicians must be endorsed by the Student Health Services before they will be accepted by the Department of Physical Education and Recreation.

2. Students who are medically exempt from a single 1000-level course including swimming will substitute another 1000-level activity course in its place, if possible.

3. Students who are medically exempt from all physical education activity courses will be required to complete PE 1040 and one hour of free electives to satisfy their physical education requirement.

XVI. Student Motor Vehicles

Students desiring to operate motor vehicles on campus are subject to all rules set forth by the Georgia Tech motor vehicle regulations.

XVII. Medical Regulations

A. General

1. No student with a contagious disease may stay in a dormitory or fraternity house or attend class. Any illness with fever should be considered a contagious disease until checked by a physician. Every student is held individually responsible for reporting such illness immediately to the infirmary.

2. A current Health Information Record and a consent-for-treatment form must be on file with the Director of Health.

B. Infirmary Regulations

Students must conform to infirmary regulations, as posted in the infirmary, while confined as patients in the infirmary.

C. Infirmary Regulations

1. To be eligible for intercollegiate athletic competition, a student must be enrolled in a degree program, carrying a work load of at least twelve credit hours, and not on academic or disciplinary probation. In addition, he or she must be making satisfactory progress towards a degree and meet any further requirements of the NCAA or other governing organization; see the athletic director for details.

2. No student may be excused from regularly scheduled classes for athletic practice.

3. No student may participate in more than two sports in intercollegiate competition in any school year, except by permission of the Office of Student Affairs. Being manager or assistant manager is counted as participation within the meaning of this rule.

XVIII. Extracurricular Activities

A. Participation

1. To be eligible for participation in extracurricular activities, a student must satisfy the following requirements:

a. be enrolled in a degree program;

b. maintain a schedule with at least six credit hours on a credit basis, or be a student in the Cooperative Division on work quarter;

c. not be on academic or disciplinary probation.

2. Participation also requires satisfaction of any additional requirements established by the Student Activities Committee of the Academic Senate.

B. Scheduling of Events

1. During the first week of each quarter, a schedule of public performances is to be sponsored by each student organization and must be submitted to the Office of Student Affairs for approval by the Student Academic and Financial Affairs Committee of the Academic Senate.

2. All student organizations must make written application to, and receive permission from, the Office of Student Affairs to hold a social function. The request must be submitted at least one week before the date of the activity, and the permission must be received before making any agreements in connection with the function.

3. In each quarter, the weekend before final examinations is closed to student sponsored extracurricular events.

C. Student Organizations

Requirements and standards for chartering a student organization are established by the Student Activities Committee of the Academic Senate and are available from the Office of Student Affairs.

D. Fraternity and Sorority Regulations

1. To be eligible for initiation, a student must be a full-time student not on academic or disciplinary probation.

2. The initiation of any individual must be registered with and approved by the Office of Student Affairs prior to the initiation.

3. The individual must meet all Georgia Tech I.F.C. requirements concerning initiation.

4. All fraternities and sororities are subject to the rules established by the Georgia Tech I.F.C.

E. Intercollegiate Athletic Regulations

1. To be eligible for intercollegiate athletic competition, a student must be enrolled in a degree program, carrying a work load of at least twelve credit hours, and not on academic or disciplinary probation. In addition, he or she must be making satisfactory progress towards a degree and meet any further requirements of the NCAA or other governing organization; see the athletic director for details.

2. No student may be excused from regularly scheduled classes for athletic practice.

3. No student may participate in more than two sports in intercollegiate competition in any school year, except by permission of the Office of Student Affairs. Being manager or assistant manager is counted as participation within the meaning of this rule.

XIX. Student Conduct Code

A. General

1. A student enrolling in the Georgia Institute of Technology assumes an obligation to conduct himself or herself in a manner compatible with the Institute's function as an educational institution. Actions considered inimicable to the Institute and subject to discipline fall into the categories of academic and nonacademic misconduct.

B. Academic Misconduct

Academic misconduct is any act which does or could improperly distort student grades or other student academic records. Such acts include but need not be limited to the following:

1. Possessing, using, or exchanging improperly acquired written or verbal information in the preparation of any essay, laboratory report, examination, or other assignment included in an academic course;

2. Substitution for, or unauthorized collaboration with, a student in the commission of academic requirements;

3. Submission of material which is wholly or substantially identical to that created or published by another person or persons, without adequate credit notations indicating the authorship (plagiarism);
4. False claims of performance for work which has been submitted by the claimant;
5. Alteration or insertion of any academic grade or rating so as to obtain unearned academic credit;
6. Deliberate falsification of a written or verbal statement of fact to a member of the faculty so as to obtain unearned academic credit;
7. Forgery, alteration, or misuse of any Institute documents or records. 
8. Any hazing action which tends to cause or allow physical or mental suffering in connection with rites or ceremonies of initiation, initiation, or orientation into Institute life, relating to the academic status of the student.

**C. Nonacademic Misconduct**

Nonacademic misconduct includes the following specifically prohibited acts whenever, unless otherwise stated, such acts occur on Institute owned or controlled property or Institute related premises:

1. Alcohol abuse, including:
   a. Conspicuous or flagrant possession of alcoholic beverage;
   b. Intoxication or condition made manifest by boisterousness, rowdiness, obscenity or indecent conduct or appearance;
   c. Possessing, using, making, or causing to be made alcoholic beverages.
2. Pushing, unjustifiably striking or physically assaulting, or otherwise intentionally threatening to endanger the person of any member of the faculty, administration, staff, or student body, or any visitor to the campus.
3. Disorderly conduct, including:
   a. Breach of the peace or obstruction or disruption of teaching, research, administration, disciplinary procedure, or any other Institute activity, including its public service functions or other authorized activities;
   b. Refusal to vacate a building, street, sidewalk, driveway, or other facility when directed to do so by any properly identified Institute faculty, administration, or staff personnel while these persons are acting in the performance of their duties;
   c. Lewd, indecent or obscene conduct or expression;
   d. Failure to comply with instructions or directions of any properly identified faculty, administration, or staff personnel while these persons are acting in the performance of their duties.
4. Drug abuse, including the use or possession (without valid medical or dental prescriptions), manufacture, furnishing, sale, or any distribution of any narcotic or dangerous drug controlled substance, which is not intended to regulate alcoholic beverages, which are covered in Section 1 above.
5. Unauthorized use of college facilities including:
   a. Unauthorized entry into any Institute building, office, or other facility or remaining in any building after normal closing hours;
   b. Unauthorized use of any Institute telephone facility or of any other Institute facilities;
   c. Possessing, using, making, or causing to be made any key for any Institute facility without proper authorization;
   d. Unauthorized use of another student or faculty member's password to gain access to the computer or computer output. This includes but is not limited to any knowing and willing use of fraudulent means to process computer programs and access computer files.

**6. Furnishing false information to any Institute official, or offering false statement in any Institute disciplinary hearing.**

7. Forgery, alteration, or misuse of any Institute document, record, or identification.

8. Any hazing action which tends to cause or allow physical or mental suffering in connection with rites or ceremonies of initiation, initiation, or orientation into Institute life, relating to the academic status of the student.

9. Safety violations, including:
   a. Intentional false reporting of a fire or any explosive device has been placed on Institute property;
   b. Tampering with fire-fighting equipment, safety devices, or other emergency or safety equipment;
   c. Setting an unauthorized fire;
   d. Possession of unauthorized fireworks, firearms, ammunition, or dangerous weapons or materials;
   e. Unauthorized sale, possession, furnishing, or use of any incendiary device or bomb;
   f. Use of smoking tobacco, in any form, in facilities or areas posted with “No Smoking” signs, or where smoking has been prohibited by any faculty member or other official.
10. Theft and/or unauthorized possession of Institute property or property of a member of the Institute community or campus visitor.
11. Malicious or unauthorized damage or destruction to Institute property or property belonging to any member of the Institute community or campus visitor.
12. Violation of rules governing residence in Institute owned or controlled property such as dormitories, family housing, fraternities, and organization housing.
13. Smoking in any form, in a facility, on the campus, or in a building when directed not to do so by any faculty member, administration staff personnel while these persons are acting in the performance of their duties.
14. Failure to remit, return, or submit financial obligations, property or records of the Institute, within the time prescribed by the Institute.
15. Tampering with fire-fighting equipment, safety devices, or other emergency or safety equipment;
17. Violation of the Regents' Statement on Disruptive Behavior, the full text of which is given in Section XX.
18. Repeated violations of the published rules and regulations of the Institute, which cumulatively indicate an unwillfulness or inability to conform to the Institute standards for student life.
19. Violation of the conduct code, wherever it may occur, violation of the laws of any city, county, state, or the United States, where the violation creates a clear and present danger of material interference with the normal or orderly processes of the Institute or its requirements of appropriate discipline.

**XX. Regents' Statement on Disruptive Behavior**

The following is the policy of the Board of Regents regarding disruptive behavior in any institution of the University System. The rights, responsibilities, and prohibitions contained in this statement are incorporated as a part of these regulations.

The Board of Regents of the University System of Georgia reaffirms its policies to support full freedom of expression by each member of the academic community and to preserve and protect the rights and freedom of its faculty members and students to engage in debate, discussion, peaceful and nondisruptive protests, and dissent. The following statement relates specifically to the problem described below. It does not change or in any way infringe upon the existing policies and practices in support of freedom of expression and action. Rather, it is considered necessary to combat the ultimate effect of irresponsible disruptive and obstructive actions by students and faculty which tend to destroy academic freedom and the institutional structures through which it operates.

In recent years a new and serious problem has appeared on many college and university campuses in the nation. Some students, faculty members and others have on occasion engaged in demonstrations, sit-ins, and other activities that have clearly and deliberately interfered with the regular and orderly operation of the institution concerned. Typically, these actions have been the physical occupation of a building or campus area for a period of time, the purpose of which has been the use of verbal or written obscenities involving indecent or disorderly conduct.

These actions have gone beyond all heretofore recognized bounds of meetings for discussion, persuasion, or even protest in that (1) acquiescence to demands of the demonstrators is the condition for dispersal and (2) the reasonable and written directions of institutional officials to disperse have been ignored. Such activities thus have become clearly recognizable as an action of force, operating outside all established channels on the campus, including that of intellectual debate and persuasion which are at the very heart of education. The Board of Regents is deeply concerned by this new problem. Under the Constitution of the state of Georgia, all university campuses, which reaches its full flowering on college and university campuses, is an essential part of American democracy, comparable to the jury system or the electoral process.

For these reasons and in order to respond directly and specifically to this new problem, the Board of Regents stipulates that any student, faculty member, administrator, or employee, acting individually or in concert with others, who clearly obstructs, disrupts, or attempts to obstruct or disrupt any teaching, research, administrative, disciplinary, public service activity, or any other activity authorized to be discharged or held on any campus of the University System of Georgia is considered by the Board to have committed an act of gross irresponsibility and shall be subject to disciplinary procedures, possibly resulting in dismissal or termination of employment.

The Board reaffirms its belief that all segments of the academic community are under a strong obligation and have a moral responsibility to protect the campus community from disorderly, disruptive, or obstructive actions which interfere with academic pursuits of teaching, learning, and other campus activities.

The Board of Regents understands that this policy is consistent with resolutions adopted by the American Association of University Professors in April, 1968, by the Association of American Colleges in January, 1968, and by the executive committee of the Association for Higher Education in March, 1968, concerning actions taken to disrupt the operations of institutions of higher education.

**XXI. Disciplinary Administration**

**A. Disciplinary Procedures**

1. All acts of misconduct (except violations of motor vehicle regulations) on the part of students shall be reported to the vice-president for Student Affairs, who is designated the principal administrator to enforce Institute disciplinary measures as they pertain to student academic or nonacademic misconduct.
2. The vice-president for Student Affairs shall investigate the alleged acts of student misconduct. If the investigation indicates that further action is necessary, the vice-president for Student Affairs shall notify the accused in writing. This written notification shall contain a statement of the nature of the alleged or suspected misconduct, and state the reasons adopted for the conduct code the student is alleged to have violated.
3. The vice-president for Student Affairs or the authorized representative will normally confer with the accused student, and at this conference the student may admit or deny the alleged violation. If the student may waive further hearing and appeal(s) in writing and request that the vice-president for Student Affairs take appropriate action, or may request a hearing as specified in 4, 5, or 6 below.
4. Case of academic misconduct will normally be referred to the Student Honor Committee, which shall hear and try cases involving academic misconduct on the part of any student.
5. Cases of serious and nonacademic misconduct which may result in suspension or expulsion will normally be referred to the Graduate Judiciary or Undergraduate Judiciary Cabinet, which shall hear and try these cases. This does not preclude possible legal actions by appropriate law enforcement agencies in those cases of nonacademic misconduct in violation of federal, state or local law.
6. If the case does not involve possible suspension or expulsion, the vice-president for Student Affairs ordinarily shall make full disposition of the case except that he or she shall at the request of the accused, or for good cause, may refer any case of nonacademic misconduct to the Graduate Judiciary or Undergraduate Judiciary Cabinet.

7. Students accused of an act of academic misconduct or nonacademic misconduct are encouraged to notify their parents or guardian of the charges. Parents or guardian will, if requested, be granted a conference with the vice-president for Student Affairs prior to the hearing.

8. An accused student will continue to attend classes and required Institute functions until the hearing is held and a decision is rendered. Exceptions to this will be made when the student's presence may create a clear and present danger of materially interfering with the Institute's normal operations or the requirements of appropriate Institute discipline. The vice-president for Student Affairs may impose temporary protective measures, including intern suspension, pending the hearing; such protective measure, if applied, will be without reasonably avoidable prejudice to the student.

B. Student Honor Committee

1. The Student Honor Committee shall consist of four members of the corps of instruction elected from the Academic Senate and two undergraduate students with at least junior standing elected by the Student Council.

2. The Undergraduate Judiciary Cabinet shall normally hear all cases of undergraduate student nonacademic misconduct in which there is possibility of suspension or expulsion of the accused student.

D. Procedural Rights of the Accused

Students accused of an act of misconduct shall be entitled to the following procedural rights:

1. Be accompanied by an advisor of their choice.
2. Remain silent with no inference of guilt drawn therefrom.
3. Question the complainant.
4. Present evidence in their behalf.
5. Call pertinent witnesses in their behalf.
6. Cross-examine witnesses.

7. In Undergraduate Judiciary Cabinet hearings the accused may challenge and unseat as many as four student justices (the chairman cannot be struck; a quorum of six student justices and the chairman must remain).

8. Appeal.

E. Hearing Procedures

1. The chairman of the appropriate hearing body shall set the date, time, and place of the hearing, shall notify the members of the hearing body, and summon all principals in the case (defendants and witnesses).

2. The chairman of the appropriate hearing body shall notify the accused student in writing at least three days in advance of the scheduled hearing. The written notification should, if reasonably possible, be hand-delivered; if not reasonably possible, notification should be by registered mail to the student's local address. The written notification should specify:
   a. The date, time, and place for the hearing.
   b. A statement of the nature of the alleged or suspected misconduct with which the student is accused, with sufficient particularity to ensure opportunity to prepare for the hearing.

3. Decisions for the hearing body shall be by majority vote. A quorum for the Student Honor Committee shall consist of five members, three faculty members, and two students. A quorum for the Graduate Judiciary Cabinet shall consist of the chairman and six justices. A quorum for the Graduates Judiciary CABINET shall consist of the chairman and four justices.

4. Members of the hearing body shall disqualify themselves if their personal involvement in the hearing is of such a nature as to prejudice the case.

5. The hearings of the Student Honor Committee, Graduate Judiciary, and Undergraduate Judiciary Cabinet shall ordinarily be closed except for the accused, the accused's advisor, and those directly involved; exceptions may be made at the discretion of the chairman.

6. The hearing body shall make a tape recording and/or summary transcription of the proceedings.

7. The hearing body shall provide a brief written summary of each case with recommendations for appropriate disciplinary action to the vice-president for Student Affairs and to the student involved.

8. The vice-president for Student Affairs will review the case and recommendations and implement disciplinary action.

F. Disciplinary Measures

For violations of Institute rules and regulations or for acts of student misconduct, academic or nonacademic, the following disciplinary measures may be taken. This list is not exhaustive and may be modified to meet particular circumstances in any case:

1. Expulsion—permanent severance of the student's relationship with the Institute.

2. Disciplinary suspension—temporary severance of the student's relationship with the Institute for a specific period of time, though not less than one quarter.

A student expelled or suspended shall leave the campus and not sit the campus during the period of suspension or expulsion, except when on official school business. To violate this stipulation would affect adversely the student's chances for readmission.

3. Reprimand—an oral or written statement of disapproval issued to the student.

4. Restriction—exclusion from participation in social activities and loss of identification card privileges.

5. Disciplinary probation—notice to the student that any further major disciplinary violation may result in suspension or expulsion; may include setting of restrictions and/or issuing a reprimand. A student on disciplinary probation is not in good standing and may not participate in extracurricular activities.

6. Fines.

7. Restitution—reimbursement for damage to or misappropriation of property; this may take the form of appropriate service or other compensation.

8. Forfeited withdrawal—withdrawal from the academic course within which the offense occurred without credit for the course.

9. Change in grade—grade change for the course in which the offense occurred.

G. Appeal Procedures

1. If accused students or accusers are dissatisfied with the action taken by the vice-president for Student Affairs, they may appeal the case in writing to the president of Georgia Tech within five days after the action about which there is a complaint. Such appeal shall recite all reasons for dissatisfaction with the previous decision.

2. The president, within five days, shall refer the appeal to the Student Grievance and Appeal Committee. This committee shall review all facts and circumstances connected with the case and shall within five days make its findings and report thereon to the president. After consideration of the committee's report, the president shall within five days make a decision which shall be final so far as the Institute is concerned.

3. The Student Grievance and Appeal Committee shall consist of three members of the corps of instruction elected from the Academic Senate and two students with at least junior standing elected jointly by the Student Council and the Graduate Senate. The chairman shall be elected annually by the committee from among the elected Academic Senate members. The secretary shall be appointed by the chairman.

4. The Board of Regents of the University System of Georgia is the final appellate authority for all cases involving students who have been suspended or expelled. Should aggrieved persons be dissatisfied with the decision of the president, they may apply to the Board of Regents, without prejudice to their position, for a review of the decision. The application for review shall be submitted in writing to the executive secretary of the Board within a period of twenty days following the decision of the president. This application for review shall state the decision complained of and the redress desired. A review of the Board is not a matter of right, but is at the sound discretion of the Board. If the application for review is granted, the Board, or a committee of the Board, shall investigate the matter thoroughly and render its decision thereon within sixty days from the filing date of the application for review or from the date of any hearing which may be held thereon. The decision of the Board shall be final and binding for all purposes.

XXII. Exceptions

Where appeals are not otherwise specified, exceptions to these regulations may be made by the appropriate faculty committee upon petition by the student and recommendation of the student's school or department. Blanket exceptions which have the effect of amending these regulations shall be referred to the Academic Senate for approval.
The University System of Georgia

Since 1932, all state-operated institutions of higher education in Georgia, including the Georgia Institute of Technology, have sought to accomplish their goals of instruction, public service, and research through their affiliation with the University System of Georgia. Governed by the fifteen-member constitutional Board of Regents under the administration of the Chancellor, the four universities, fourteen senior colleges, and fifteen junior colleges that compose the System retain a high degree of autonomy while cooperating with member institutions within the structure of Board policy. In addition to the formulation and administration of policy, the Board of Regents is responsible for requesting appropriations from the Georgia legislature and for allocating these funds to member institutions.

To provide students in Georgia with quality instruction leading to a variety of degrees, the Board of Regents establishes minimum academic standards, granting to each member institution the prerogative of establishing higher standards. In addition, the Board has instituted a core curriculum for freshmen and sophomores whose educational goal is a degree beyond the associate level, in order to facilitate the transfer of credit within the University System. This curriculum requires ninety quarter hours in general studies—humanities, social sciences, mathematics, and natural sciences—and thirty in the student's chosen major area.

Besides providing a foundation for sound instruction, the Board encourages public service and continuing education programs including lectures, conferences, short courses, advisory services, extension courses, and teacher education consortiums. The Board also encourages research related to the educational objectives of the institutions and originating in societal need.
Member Institutions

Degrees Awarded: A—Associate; B—Bachelor’s; J—Juris Doctor; M—Master’s; S—Specialist in Education; D—Doctor’s; cD—Doctor’s, offered in cooperation with a University System university, with degree awarded by the University.

Universities

Statesboro 30460
Savannah 31404
Savannah 31406
Milledgeville 31061
Marietta 30060
Fort Valley 31030
Columbus 31993
Carrollton 30118
Augusta 30910
Brunswick 31523
Bainbridge 31931
Waycross 31501
Augusta 30912
Atlanta 30303
Atlanta 30332
Athens 30602

Senior Colleges

Valdosta 31698
Statesboro 30460

cD—Doctor’s, offered in cooperation with a University System university, with degree awarded by the University.
**Georgia Tech Research Institute**
Donald J. Grace, Ph.D., director
Gerald J. Carey, M.S., associate director
H.G. Dean, B.S., associate director
Robert G. Shackelford, M.S., associate director
James C. Wilse, Ph.D., associate director

**Graduate Studies and Research**
Walter O. Carlson, Ph.D., P.E., associate vice-president and dean
Helen E. Grenga, Ph.D., director, Graduate Cooperative Program

**Information Technology**
Jesse Poore, Ph.D., associate vice-president
John Gehl, M.S., acting director, Computing Services
R.H. Childs, M.S., associate director, Computing Services
Jerry W. Segers, B.S., director, Telecommunications and Networking
Gary G. Watson, M.S., director, Information Systems and Applications

**Institute Relations and Development**
Warren Heemann, M.A., vice-president
Cecil R. Phillips, M.S., associate vice-president
John P. Culver, M.A., assistant vice-president
Dell B. Sikes, B.S., assistant vice-president
John B. Carter, B.S.I.M., director, Marketing, Georgia Tech Alumni Association
John C. Dunn, B.A., director, Alumni Publications, Georgia Tech Alumni Association
Charles E. Gearing, Ph.D., director, Cooperative Liaison Program
Charles E. Harmon, A.B., director, News Bureau
Catherine C. Inabnit, M.S., director, Constituency Research
Bonnie B. Johnson, B.A., director, Special Gifts
Robert N. Leitch, J.D., director, Planned Giving
Linda W. McNay, M.B.A., director, Annual Giving

Mary Kay Murphy, Ph.D., director, Foundation Relations
James B. Osborne, Ed.D., director, Corporate Relations and Placement
Mary E. Stoffregen, M.P.A., director, Accounting and Administration
Thomas L. Vitale, B.F.A., director, Publications

**Interdisciplinary Programs**
J.M. Spurlock, Ph.D., director, Interdisciplinary Programs and director, Bioengineering Center
Frederick A. Rossini, Ph.D., associate director, Interdisciplinary Programs, and director, Technology Policy and Assessment Center
S.D. Antolvich, Ph.D., director, Fracture and Fatigue Research Laboratory
S. Aturi, Sc.D., director, Computational Mechanics Center
M.W. Carter, Ph.D., director, Center for Radiological Protection
Eric Clayfield, Ph.D., director, Georgia Mining and Minerals Resources Institute
D.S. Clifton, Ph.D., acting director, Georgia Productivity Center
R.B. Gray, Ph.D., director, Center for Excellence in Rotary Wing Aircraft Technology
J.W. Hooper, Ph.D., director, Microelectronics Research Center
B. Kahn, Ph.D., director, Environmental Resources Center
R.A. Karam, Ph.D., interim director, Nuclear Research Center
R.J.L. Martin, M.I.D., director, Rehabilitation Technology Center
J.H. Myers, M. Arch., director, Center for Architectural Conservation
J. Pettigrew, Ph.D., director, Communication Research Center
M.E. Thomas, Ph.D., acting director, Health Systems Research Center
T.G. Tornabene, Ph.D., director, Center for Research in Biotechnology
J.A. White, Ph.D., director, Materials Handling Research Center
### Full-Time Academic Faculty and Administrators

**As of January 2, 1985**

After each name the highest earned degree and its source is listed. The academic rank is followed by the individual’s major assignment. Professional registration is indicated with the state(s) of registration as follows:


<table>
<thead>
<tr>
<th>Name</th>
<th>Degree and Source</th>
<th>Major Assignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agaram S. Abhiraman, Ph.D.</td>
<td>North Carolina State University, Raleigh</td>
<td>Associate Professor, Chemical Engineering</td>
</tr>
<tr>
<td>Philip Adler, Jr., Ph.D.</td>
<td>Ohio State University</td>
<td>Professor, Management</td>
</tr>
<tr>
<td>Pradeep K. Agrawal, Ph.D.</td>
<td>University of Delaware</td>
<td>Assistant Professor, Chemical Engineering</td>
</tr>
<tr>
<td>R. Martin Ahrens, Ph.D.</td>
<td>Washington University</td>
<td>Professor, Physics</td>
</tr>
<tr>
<td>James M. Akridge, M.S.</td>
<td>University of Maryland</td>
<td>P.E. (Georgia)</td>
</tr>
<tr>
<td>Faiz A. Al-Khayyal, Ph.D.</td>
<td>George Washington University</td>
<td>Visiting Assistant Professor, Industrial and Systems Engineering</td>
</tr>
<tr>
<td>Marion R. Alexander, M.S.</td>
<td>Naval Postgraduate School</td>
<td>Associate Professor, Naval Science</td>
</tr>
<tr>
<td>Cecil O. Alford, Ph.D.</td>
<td>Mississippi State University</td>
<td>Professor, Electrical Engineering</td>
</tr>
<tr>
<td>Phillip E. Allen, Ph.D.</td>
<td>University of Kansas</td>
<td>Schlumberger Professor, Electrical Engineering</td>
</tr>
<tr>
<td>Douglas C. Allen, M.L.A.</td>
<td>Harvard University</td>
<td>L.A. (Kentucky)</td>
</tr>
<tr>
<td>Fred C. Allvine, D.B.A.</td>
<td>Indiana University, Bloomington</td>
<td>Professor, Management</td>
</tr>
<tr>
<td>William F. Ames, M.S.</td>
<td>University of Wisconsin</td>
<td>Director and Regents’ Professor, Mathematics</td>
</tr>
<tr>
<td>Jane C. Ammons, Ph.D.</td>
<td>Georgia Institute of Technology</td>
<td>Assistant Professor, Industrial and Systems Engineering</td>
</tr>
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