ENGINEERING AT CORNELL

1966 1967

CORNELL UNIVERSITY ANNOUNCEMENTS

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This Announcement is intended to serve as an outline of the opportunities available to students considering the College of Engineering at Cornell. Detailed information concerning the various curricula and courses are described in *College of Engineering: Courses and Curricula,* which may be obtained by writing to the Announcements Offce, Edmund Ezra Day Hall, Cornell University, Ithaca, New York 14850.

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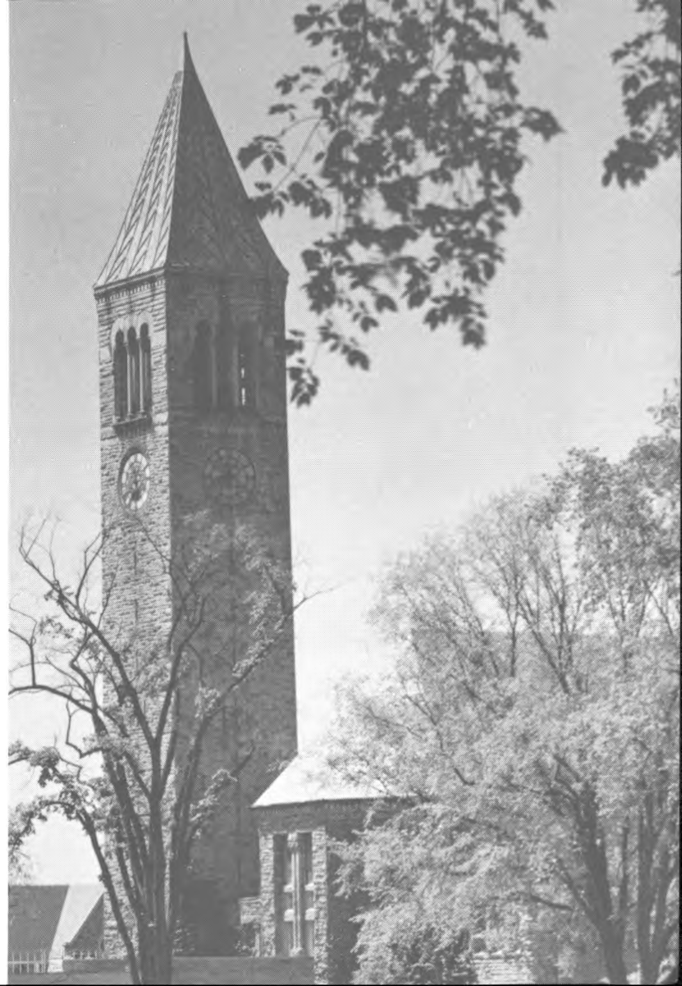
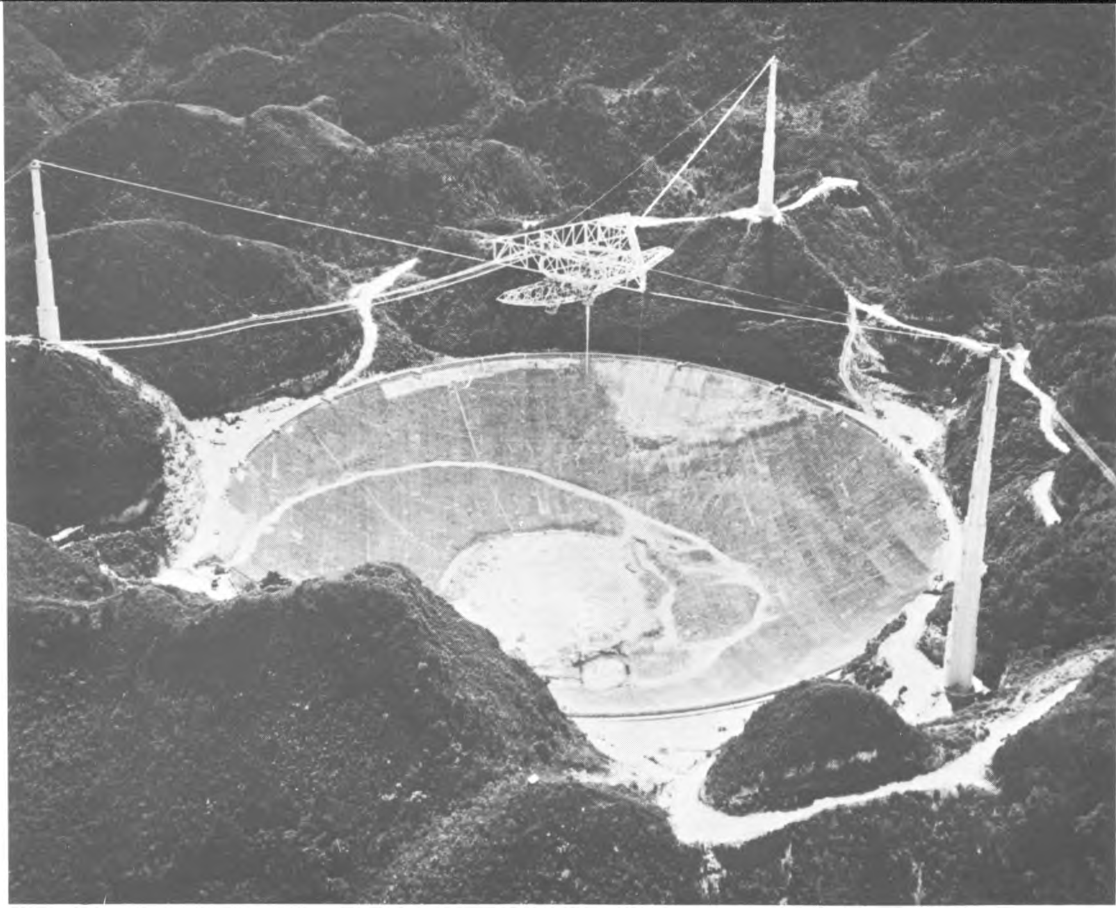


INTRODUCTION

The education of today's engineer for tomorrow's needs reflects the constancy of change in our environment. The majority of engineering students now pursue formal education for a more extended period of time than did their predecessors of a generation ago. Such pursuit recognizes the increasing sophistication of modern professional engineering practice. The range of activity in which engineers are involved is also broadening; we find countless examples of contemporary engineering operations that were unknown even a few years ago. This development highlights the necessity for a sound pre-professional education which will equip today's graduate for tomorrow's requirements. In addition, these new and diverse professional goals call for greater flexibility in program planning on the part of faculty and students.

In this Announcement, Cornell's new degree programs are described, along with the areas and facilities for specialized study. Both curricular and extracurricular opportunities open to Cornell's engineering students have been included. Any student seriously contemplating a career in engineering, however, is strongly encouraged to seek out and talk with professional engineers in his community, to explore his area industries, and to observe what engineers do in them. He should visit at least one engineering campus and ask its students what their studies are all about. He should also make use of the literature available through his guidance office and the school and community libraries to read about the engineering profession.

Only by doing these things can a prospective student hope to determine, in advance of college, whether he has the abilities plus the motivation to undertake a demanding, but for most, a highly rewarding career preparation. The choice of an academic program is difficult; so is the choice of a college itself. Thoughtful consideration of these choices, by any college candidate, will insure a more rewarding and successful college experience.



Aerial view of the Arecibo radar-radio telescope, the world's largest, located in Puerto Rico. The telescope was conceived and designed by faculty members of the College of Engineering and is now operated by the University.

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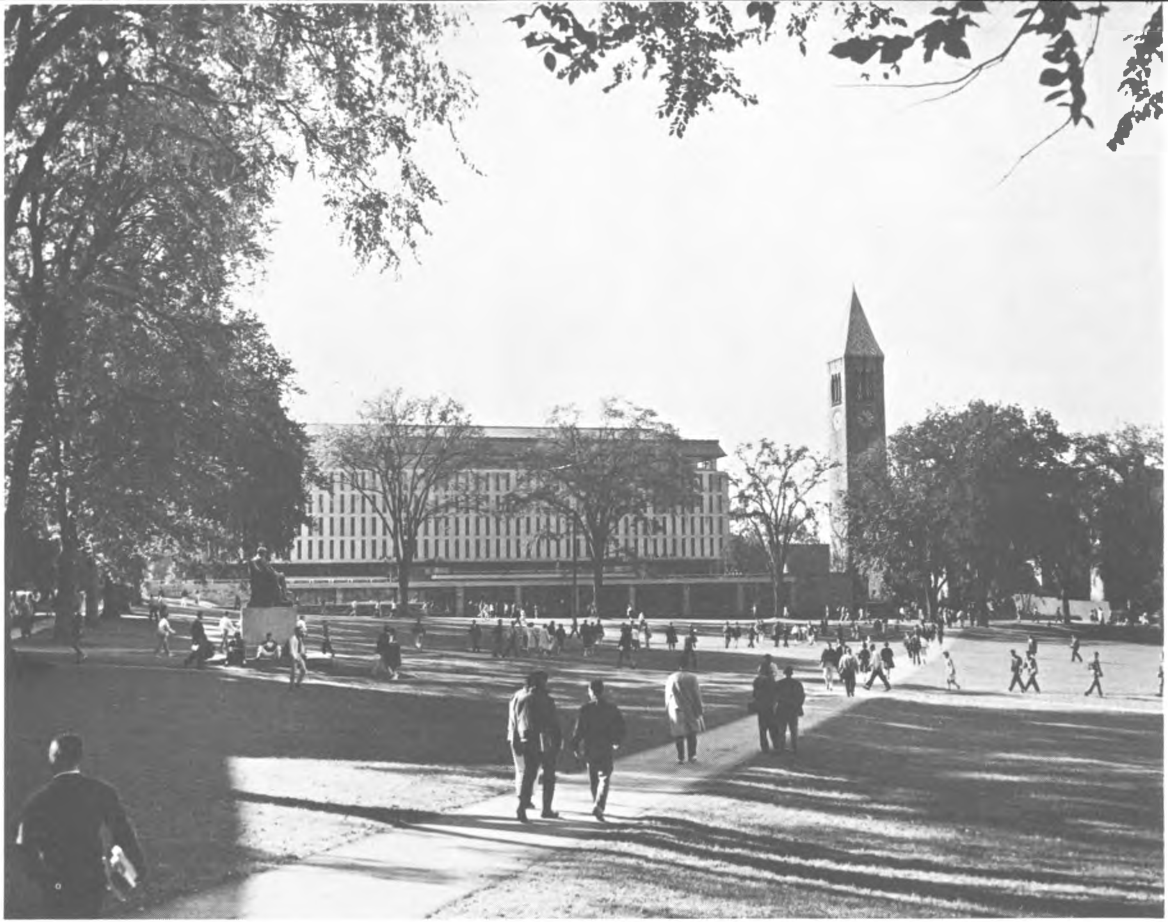


The McGraw Tower of the Uris undergraduate library is a familiar campus landmark. The new Olin Library for research and graduate study is in the foreground.

If you like mathematics *and* do well at it; if you have enjoyed what science courses you may have had; if you think you would like to apply the principles of these studies to create systems for useful purposes, then you probably have the ability and interest to consider a career in engineering. Engineers shape the discoveries of science to meet diverse human needs. Machines which transform energy into usable power, highway and building construction, manufacturing processes, the design of communication systems, and experimental work on new materials and chemical processes are but a small part of the spectrum of opportunities awaiting the young engineering graduate. What engineers do is sometimes routine, but more often than not it is exciting. The energies of engineers are having a profound effect in shaping the direction of our dynamic civilization.

Engineering requires the best that is in you and helps develop that best. It is a rigorous and demanding intellectual discipline and an excellent training of the mind. The bridge builder or missile maker cannot afford to be right only 70 per cent of the time, because the safety, comfort, convenience and economy of millions of people are affected by his ability or lack of it. To be a success in engineering you must be able to concentrate, systematize, and organize your work; make an orderly approach to solving problems; and persist in spite of repeated failures.

The decision to enroll in engineering is not quite the same as a decision to undertake a program in liberal arts. Those students who study the humanities, or the natural or social sciences, are learning about their cultural heritage or the world around them but are not necessarily preparing for a specific professional career. As a result, liberal arts students can do a good bit of experimenting before they have to decide on their major field. In a sense, the engineering student has chosen his program of studies before he arrives on campus for his freshman year. It is important to note that he has made this choice understanding that engineering is a highly developed profession like law or medicine. The liberal arts student, while he obtains a broader cultural background, must, if he seeks professional training in his undergraduate field or in law or medicine, enter graduate school.

For the student in engineering a university like Cornell provides educational opportunities not available in a self-contained college where engineering and science are the dominant studies. Through a generous elective program, especially during the upperclass years, engineers can explore a broad spectrum of human knowledge.

For example, Cornell students are investigating the nature of man and his thought in such departments as philosophy and psychology, or social theories and organizations in economics,

CORNELL ENGINEERING

government, history, sociology, and anthropology. Strong departments of chemistry, physics, and astronomy conduct and offer studies in the nature of the physical world and the universe. Organic life is studied in such departments as botany, biology, entomology, and zoology, and the dimensions and structure of the earth in geology and geography.

In departments devoted to literature, languages, art, music, architecture, drama, and classics, the expressions of man's spirit and his cultural heritage, in this and other nations, are explored.

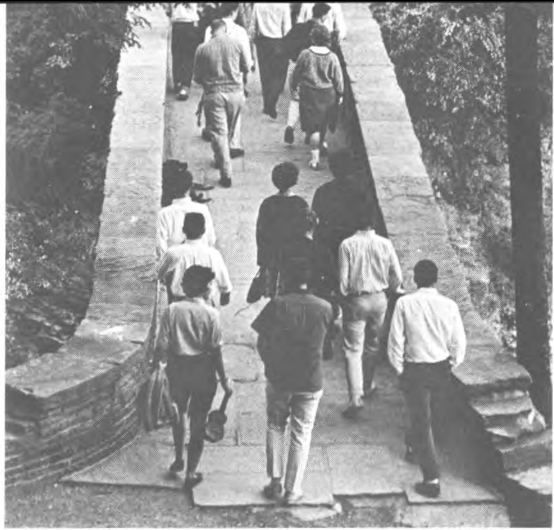
Teachers in all Cornell departments are leaders in their field. Professor Clinton Rossiter, noted authority on American government and political thought, draws students from all parts of the campus. Professor Thomas Gold not only heads the Department of Astronomy, but in the School of Electrical Engineering he teaches electromagnetic wave propagation in the ionosphere and the solar system. Students can study the origins of modern science in the history of science courses offered by Professors Henry Guerlac and L. Pearce Williams. Many seek out Professor Milton Konvitz's course, "Development of American Ideals," in the School of Industrial and Labor Relations.

There are no special electives designed for engineers. They must first of all fulfill the exacting requirements of their own curricula and schedules, and it is true that the demands of these are more stringent than the demands confronting most students in non-professional curricula. Nevertheless, the latitude is considerable, and the list of courses elected by engineering students ranges through every college of the University.

CORNELL'S PIONEERING EDUCATIONAL TRADITION

Ever since its founding in 1865, Cornell has been a pioneer in engineering education. As one of a handful of university engineering schools of that era, Cornell substantially led in the development of a broader educational pattern for engineers, notably in the integration of technical and non-technical studies. The first engineering degrees awarded by Cornell were granted in 1871 in the field of civil engineering. They were followed in 1873 with the awarding of the first Cornell degrees in mechanical engineering.

In 1883 the first program in electrical engineering in the United States was announced by Cornell. During the same year, the Massachusetts Institute of Technology announced a similar course. Each school had graduates from these two courses in 1885, making these men the first electrical engineers in America. However, it



Left: Crossing over Cascadilla gorge on a late spring afternoon.

Below: Willard Straight Hall, Cornell's student union.

should be recalled that Cornell had long been associated with the electrical field in other ways. Ezra Cornell, the founder of the University, had been employed in 1843 by Samuel F. B. Morse to construct an experimental telegraph line between Washington and Baltimore. The final method of constructing the line was proposed by Cornell and approved by Professor Joseph Henry, then the leading physicist in the field of electricity. It was over this line that the famous first intercity message was sent by Morse on May 14, 1844, "What hath God wrought!"

Graduate work in engineering began at Cornell in 1870, with the granting of the degree of Civil Engineer. The first doctorate granted at Cornell for advanced study in engineering was given in 1872 to a graduate student in civil engineering. This was the first Doctor's degree awarded by the University. In 1885 the first doctorate in electrical engineering was granted. A second in this field was awarded in 1892. The first doctorate in hydraulics was awarded in 1896.

Sigma Xi, national scientific fraternity, was founded in the Sibley College of Mechanical Engineering at Cornell by Professor Henry Shaler Williams.

In recent years, Cornell has been a major force in influencing growth in graduate education, or education beyong the traditional four years of undergraduate study. In 1946, it established a five-year educational pattern as a minimal period to develop professional competence in an engineering discipline. Since that time the proportion of engineering graduates across the United States continuing their study beyond four years has increased nearly exponentially. Today, it would be difficult for a young graduate with less than five years of education in engineering to perform creatively in most modern engineering activities.

Sophomore engineers in an engineering science lecture in Kimball Hall.

With the ever-diminishing time span in which an idea is created and ultimately translated into practical application, engineers in future years must be more capable of finding solutions to problems which cannot be solved with a knowledge of familiar machines, existing organizations, and known structures. Therefore, Cornell places a firm emphasis on mathematics, physics, and chemistry, and the application of their principles to basic engineering problems and situations. Such a mastery of fundamentals makes it possible to keep up with what is and what *will* be new.

The best way to study engineering is to gain a firm hold on fundamentals; but the best way to learn what directions the use of those fundamentals is taking, is to be where new frontiers are being explored through research. The engineering faculty itself conducts such research, directs graduate students, and advises senior undergraduates on their own independent projects.

Fundamental research is conducted in all established engineering fields. But research is also being conducted in new fields not bound by traditional lines. The Center for Radiophysics and Space Research, for instance, brings together investigators in astronomy, engineering physics, electrical engineering, physics, and aerospace engineering. They are studying the atmosphere and properties of space near the planets, development of space vehicle instrumentation, and use of radio astronomy for investigating the solar system and our own and other galaxies. This Center's principal facility, the Arecibo Ionospheric Laboratory in Puerto Rico, is but one example not only of an engineering idea being translated to operational reality but of the commitment which is Cornell's — moving well out on the frontiers where new knowledge may be found. A 1000-foot radar-radio telescope (or "big ear") is the principal facility of that Laboratory.

The Water Resources Center is another illustrative organization designed to encourage graduate study and research in the field of water resources with a strong correlation to subjects in many other fields. A comprehensive program in water resource planning and management will be related to the sciences, to engineering, to law, to agriculture, and to economics.

Studies like those in Cornell's Nuclear Reactor Laboratory, interdisciplinary Materials Science Center, and Computing Center bring the excitement of discovery into the undergraduate classroom. They enable the traditional branches of engineering to participate in the newest developments and help students to define future engineering problems and opportunities.

Research at Cornell is not a separate entity but is a planned part of the whole educational program.

Cornell engineering seeks to graduate men

THE DEGREE PROGRAMS

who understand the meanings of their profession in the world of affairs; who can express themselves and their profession clearly, intelligently, and resolutely; who have had the opportunity to gain insight into man, the arts, and the structure of society.

THE PROGRAMS

Greater opportunities and *choice* — these are the key concepts which best describe the programs of study now available in Cornell's new curricula. *Greater opportunities* lie in the added dimension described below as the College Program. The College Program is a unique educational pattern for an engineering college, and enables a student, with his adviser, to develop an individually distinctive program of studies. *Choice* is implicit in both the Field Programs and the College Program. A student now has, however, a greater degree of flexibility in making his decisions than formerly.

For example, all students enrolled as freshmen take the same courses. Beginning in their sophomore year, they can now choose 60 percent of their program, consistent with the *core studies requirement (see* the section "The Common Studies Core"). Their experience in these courses enables them to focus on a few subject areas which can help them in the choice of either a Field Program or a College Program. Beginning in the junior year then, a student commits himself to one of those programs. Each program leads to a Bachelor of Science degree at the end of the senior year (or fourth year of study in the College).

At the graduate level, the student is once again able to exercise choice in the range of opportunities open to him. One principal path leads to the professional Master's degree and the other to the regular Master of Science degree or to the Ph.D.

Most students who follow one of the undergraduate Field Programs will undoubtedly desire to earn a professional Master's degree. There will be fifth-year professional Master's degree programs in each of the fields, in addition to aerospace engineering and nuclear engineering. In most cases these curricular programs will be integrated with the undergraduate programs of the same field. The main change from the fourth to the fifth year will be in level and character of studies.

Many students who follow an undergraduate College Program will probably want to work toward the Master of Science degree or, in some cases, the doctorate. The door to a professional Master's degree program will not be closed to them however, nor will there be any reason why a graduate of a Field Program, motivated toward research, could not study for the Master of Sci-

Opposite: Freshman engineers examining close-up detail of a drawing used in the study of design of engineering systems.

ence degree. Qualified professional Master's degree holders can also seek the Ph.D. The Master of Science program will be directed by the Graduate School of the University, just as at present. The student may take any one of the major and minor combinations currently available. It is expected that most will major in one of the established areas of engineering or applied science in the Graduate School. Some may want to undertake graduate or professional study in other fields such as law, business, public administration, or medicine — to name but a few. The provisions of the undergraduate College Program should facilitate entry into such professional programs.

Admission to either path of the fifth year — the professional Master's or the Master of Science and Ph.D. — will be on an individual basis and will require evidence of ability for the successful pursuit of graduate work.

THE COMMON STUDIES CORE

One of the goals of the new curricula is to foster the development of a sound education which can be directed toward a wide choice of careers in engineering and applied science. Studies during the junior and senior years, as well as subsequent graduate work in the College, will complement the course work included in the core. Two-thirds of the credit hours in

the College's new undergraduate programs are included in this core, with the remainder devoted to the development of a specific educational goal in either one of several Field Programs or the College Program. (Both Field Programs and the College Program are described in other sections of this Announcement.)

All freshmen will take a common program of studies, except those obtaining advanced placement. Mathematics, physics, chemistry, and English are included in the freshman year. In addition, one introductory engineering course taught by members of the engineering faculty is offered each term. One of these introduces fundamentals of engineering graphics and the role that the design function plays in modern engineering. The other course stresses the functions of modern engineering, the nature of engineering, and the interrelationships of several professional fields. Freshmen learn CORC, the Cornell computing language, while enrolled in this latter course, and make subsequent use of it in their mathematics, science, and engineering courses. Both of these introductory courses encourage close student-faculty association. The relationship with advisers drawn from the College's faculty provides another way for students to become acquainted with the many opportunities open to them in the Cornell programs.

During the sophomore year the core includes further work in mathematics and physics and a liberal studies course in each term for all students. To round out the sophomore year, two engineering science courses are chosen by a student each term. It is intended that these serve as the mechanism linking his work in mathematics and sciences with studies in the upperclass engineering program. There are several engineering sciences which can be selected by the student. The choice is governed by the program which the student desires to enter in his junior year. Some fields require two engineering science courses, others one, for admission to their programs in the junior year.

Opposite: A freshman engineering lecture. This program includes problem analysis and synthesis, computer programming, and engineering economics.

Below: At work in the electrophysics laboratory in electrical engineering.

ENGINEERING GRAPHICS AND DESIGN 103
Fundamentals of the engineering graphic language, including orthographic drawing and sketching, pictorial drawing and sketching, auxiliaries, sections, intersections, and developments. Instrument drawings will show applications of visual communication in the design process. Freehand conceptual design.

and

ENGINEERING 104
Orientation to the engineering profession: discussion of curriculum, engineering functions, engineering fields, and introduction to technical report writing.
Digital computing: machine language, problems, and computer applications.
Engineering design: analysis of factors such as safety, reliability, efficiency, and economy that contribute to sound design.

CALCULUS FOR ENGINEERS 191-192
Fall: Plane analytic geometry, differential and integral calculus, applications.
Spring: Transcendental functions, technique of integration and multiple integrals, vector calculus, analytic geometry in space, partial differentiation applications.

INTRODUCTORY ANALYTICAL PHYSICS 121-122
The mechanics of particles: kinematics of translation, dynamics, conservation of energy. The properties of the fundamental forces: gravitational, electromagnetic, and nuclear. Conservation of linear momentum, kinetic-molecular theory of gases, properties of solids and liquids, mechanics of rigid bodies, harmonic motion.

GENERAL CHEMISTRY 107-108
The important chemical principles and facts are covered, with considerable attention given to the quantitative aspects and to the techniques which are important for further work in chemistry. Second-term laboratory includes a simplified scheme of qualitative analysis.

or

GENERAL CHEMISTRY AND INORGANIC ANALYTICAL CHEMISTRY 115-116
A general study of the laws and concepts of chemistry based upon the more common elements, and application of the theory of chemical equilibrium to the properties and reactions of ions of the common elements and their separation and detection in solution.

FRESHMAN HUMANITIES COURSES
(One course each term)
English: Several one-semester courses, each con-

are offered in specific areas in English and American literature, relation of literature to culture, and various forms of writing (narrative, biographical, expository).

or

Humanities: Choice from among special courses in European history, German literature and translation, history of art, and philosophy. Special emphasis is placed on written composition and development of thought in these offerings.

There are *honors* sections offered in Mathematics 192, spring term, for superior performance in the fall term. Advanced placement is available in mathematics to freshman matriculants as well.

In both Physics 121 and 122, the class is sectioned according to achievement and aptitude. Advanced placement is offered in chemistry, and well qualified students are encouraged to enroll in Chemistry 115-116.

Half of the freshman class is enrolled in Engineering 103 during the fall term while the other half is in Engineering 104. During the spring term, each student completes that course in which he was not enrolled during the fall term.

An afternoon tutoring session for freshman students.

Students working in small teams, a unique feature of the physics laboratory sequence.

ENGINEERING MATHEMATICS 293-294
Vectors and matrices, first order differential equations, infinite series, complex numbers, applications. Linear differential vector calculus, applications. Problems for programming and running on the computer will be assigned, and students are expected to have a knowledge of computer programming equivalent to that taught in Engineering 104.
Spring: Linear differential vector calculus, applications.

INTRODUCTORY ANALYTICAL PHYSICS 223-224
A survey of electric and magnetic fields including a review and an extension of the study of static fields and their sources. Fields in simple dielectrics, charges in motion, time-varying fields, induced electromotance, fields in magnetic materials, energy of charge and current distribution, electrical oscillations, electromagnetic field relations. Wave motion with emphasis on the properties of electromagnetic waves; reflection, refraction, dispersion, and polarization. Superposition of waves; interference and diffraction. Selected topics from contemporary physics such as relativity, quantum effects, atomic and X-ray spectra, nuclear structure and reactions, solid state physics. The laboratory work includes ex-

electronics, optics, and nuclear physics.

metal electromagnetic pump in an electrical laboratory.

LIBERAL STUDIES

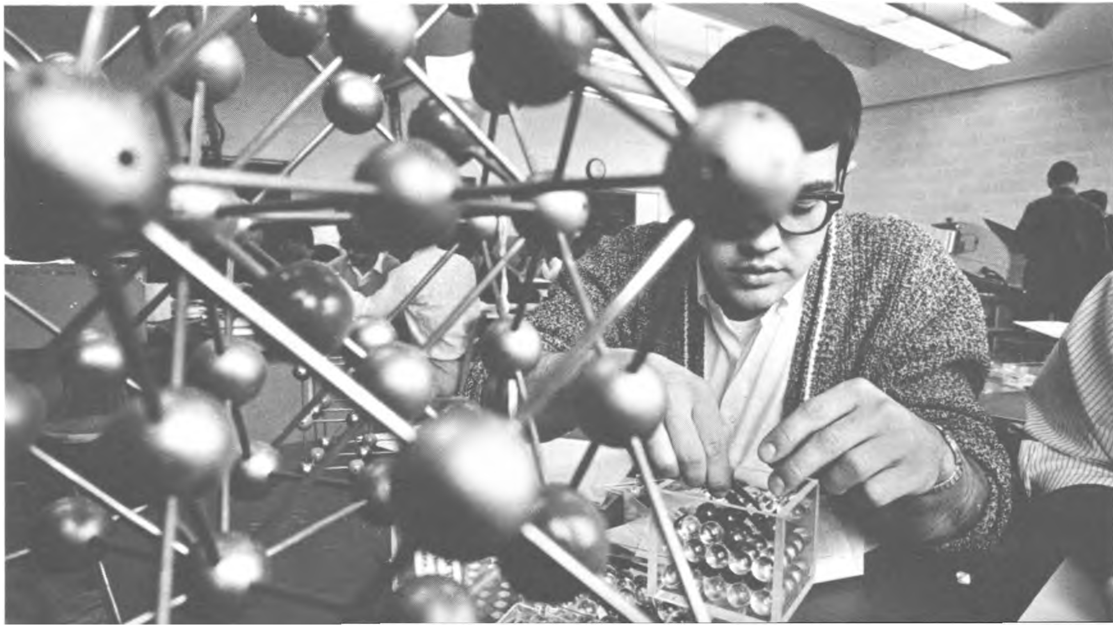
Elective (one per term.) Choice from: *Humanities:* English, fine arts, philosophy, literature, music, classics, and speech and drama. *Social Studies:* Economics, government, history, psychology, sociology, and anthropology. *Languages.*

ENGINEERING SCIENCE ELECTIVES
(Any two of the following sequences)

ELECTRICAL SCIENCE 241-242
Fall: The elements of circuit analysis as applied to circuits of resistive and capacitive elements and their applications. Electronic circuit elements and their characteristics.
Spring: Vacuum tube and transistor behavior and design considerations as they affect signal characteristics. Power and energy handling, efficiency considerations, electromagnetic devices and measurement applications.

MECHANICS OF RIGID AND DEFORMABLE BODIES 211-212
Fall: Force systems and equilibrium. Distributed forces, static friction, statically determinate plane structures. Concepts of stress and strain. Shearing force, bending moment, bending and torsion

In a materials science laboratory students learn about the structure of matter.



of beams. Analysis of plane stress and strain, combined stress, thermal stress. Theories of failure. Instability of columns.
Spring: Inelastic behavior. Energy methods in mechanics. Principles of particle dynamics. Theory of oscillations. Kinematics of rigid body motion.

MATERIALS SCIENCE SEQUENCE
(The two courses following)

INTRODUCTION TO PHYSICAL CHEMISTRY 276
Atomic structure; properties of gaseous, liquid and crystalline substances; thermochemistry; equilibrium in homogeneous and heterogeneous systems; surface and electrochemistry.

and

MATERIALS SCIENCE: ENGINEERING 6211
Lectures and laboratory. A fundamental course considering stable and metastable aggregations of atoms into real materials, the properties of materials, and the relationship of structure to properties. The effect of mechanical and physical forces on the properties of materials are treated. The laboratory includes experiments on crystallography, phase equilibria, microscopy, crystal imperfections, diffusion, and mechanical properties.

INTRODUCTORY PHYSICAL CHEMISTRY 285-286
(For students planning to major in chemical engineering)
The lectures will give a systematic treatment of the fundamental principles of physical chemistry. The laboratory will deal with the experimental aspects of the subject and also develop the needed skills in quantitative chemical analysis.

Engineering graphics and design are taught as part of the freshman engineering common program.

MASS AND ENERGY BALANCES 5101
(For students planning to major in chemical engineering)
Fall: Engineering problems involving material and heat balances. Flowsheet systems and balances. Total energy balances for flow systems.

and

EQUILIBRIA AND STAGED OPERATIONS 5102
(For students planning to major in chemical engineering)
Spring: Phase equilibria and phase diagrams. The equilibrium stage; mathematical description of single and multistage operations; analytical and graphical solutions.

FIELD PROGRAMS

Students intending to enter practice in one of the several traditional engineering fields taught by the College will enroll in a Field Program in their junior year. At present, Field Programs are offered in chemical, civil, electrical, and mechanical engineering in addition to engineering physics, materials science and engineering, and industrial engineering and operations research. To prepare for entry to one of these fields, the appropriate engineering science courses would be selected during the sophomore year (see the Common Studies Core). For example, a student considering electrical engineering would take courses in electrical science and mechanics as his preparatory engineering science courses.

In any of these several fields, further core studies are continued through required liberal electives, free electives, and additional engineering science electives. Approximately 30 per cent of the four-year program is devoted to professional studies of a chosen field.

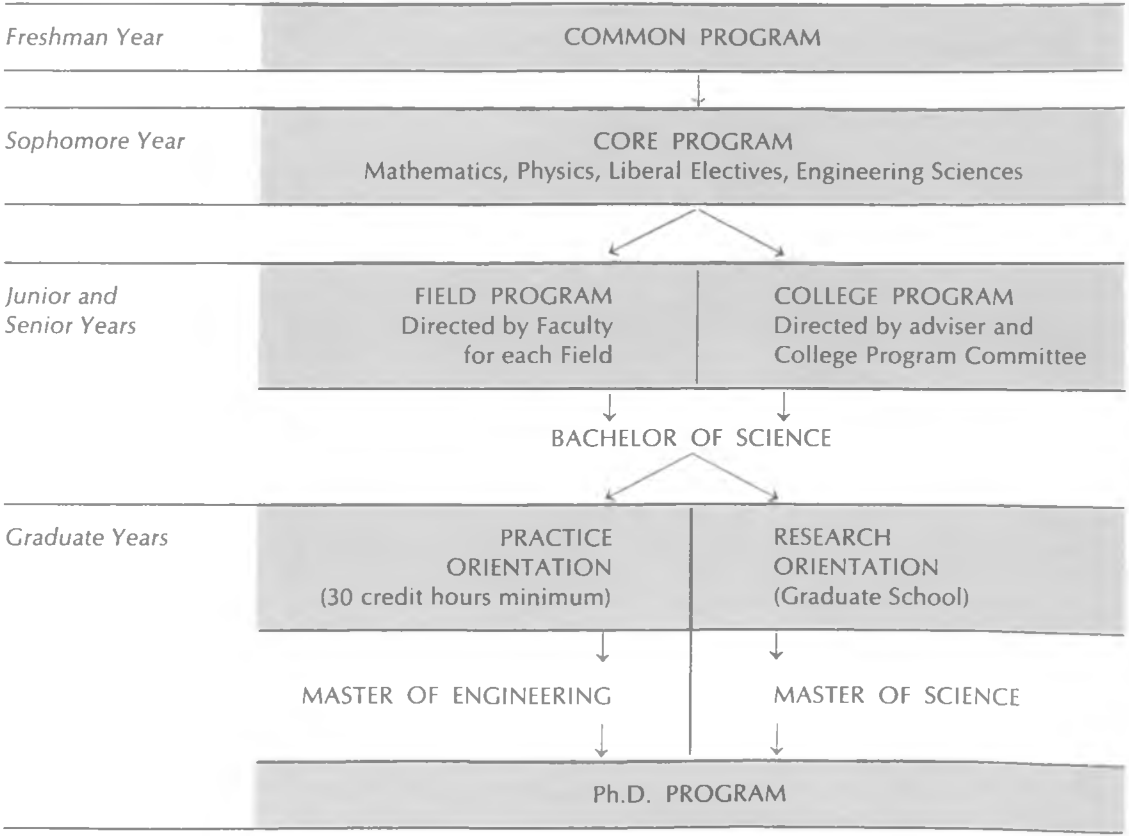
At the completion of the four-year Field Program, a graduate may be admitted to the College's professional Master's degree program, earning the degree in one additional year. The professional Master's degree program represents the level at which graduates will be prepared to seek *professional* engineering employment. The degree includes advanced work in a field begun formally during the junior year and represents a three-year program of integrated studies particularly suited to the requirements of modern engineering practice.

Individuals seeking careers in research in applied science or in a specialized engineering area, such as thermal engineering, a portion of the mechanical engineering field, can apply for the Master of Science or the Ph.D. program at the end of the four-year Bachelor's degree.

Some students may desire to undertake graduate or professional study in other fields such as law, business, public administration, urban planning, or medical research. It will be their

Opposite: Relaxing after a lecture in Phillips Hall of Electrical Engineering.

OUTLINE OF CORNELL'S DEGREE PROGRAMS



decision as to which level of preparation they seek in engineering — the Bachelor of Science degree or the professional Master's degree — before embarking on other studies.

The Bachelor of Science degree in a field program may be the terminal point in the formal education of some students, but it is expected that most will continue formal studies beyond this stage.

THE COLLEGE PROGRAM

The College Program has been established to accommodate those students whose educational objectives require more curricular flexibility than is possible in the various Field programs. Depending on his objective, a student enrolled in the College Program may combine sequences of courses from two or more engineering fields or an engineering course sequence combined with one in a non-engineering discipline.

The College Program requires the same core curriculum as the Field programs (which accounts for approximately 70 per cent of the undergraduate program). However, it differs from the Field programs since a student suggests his own program of studies when he applies for admission to the College Program. Such admission will normally be at the beginning of his junior year, but applications to the program will be accepted as early as the second term of the freshman year.

A variety of interests can be satisfied through the College Program, and the College Program Committee, which administers the program, will approve all proposals that are logically related to an educational objective having an engineering foundation. Some of the College Programs now under way include the following:

Electrical engineering and biology.

Mechanical engineering and industrial engineering.

Civil engineering and architecture.

Electrical engineering and industrial engineering.

Civil engineering and geology.

Civil engineering and materials science.

Many more arrangements are possible since

Preparing a materials sample in the Edward Bausch Laboratory of Metallography, part of Bard Hall's facilities.

Cornell offers an unusually wide range of courses in all its various undergraduate colleges and schools.

One of the features of the College Program is that it gives students and faculty alike the opportunity to pioneer in new areas of engineering and applied science. Many of these new areas cannot be successfully developed within a Field since, in most instances, they represent the interests of several fields.

At the end of four years of study, a Bachelor of Science degree is awarded, as in a Field Program. For many who complete the College Program, the Master of Science degree or, in some cases, the doctorate, directly, may be pursued. Opportunity to earn a professional Master's degree is dependent upon the student's choice of a major within the College Program and the courses taken in that major.

THE INDUSTRIAL COOPERATIVE PROGRAM

During the fourth term, an above-average student who intends to pursue a program in electrical, industrial engineering and operations research, mechanical engineering, or engineering physics, may apply for admission to the Industrial Cooperative Program.

If accepted in that program he will have an opportunity to gain practical experience in his chosen field, which can be of value to him in planning his program and carrying out his studies. In addition, he not only earns a substantial salary during his periods of employment but also gains about a year in the amount of responsibility he can undertake upon graduation.

By utilizing the summers following his second, third, and fourth years, the student is able to complete the academic requirements for his Bachelor's degree, pursue his work program totaling nearly one year in industry, and still graduate with his class on time. He is on campus with his classmates except during the fifth term.

The schedule for the Cooperative Program, beginning after the fourth term, is as follows:

Summer	Fifth Term Courses
Fall	Industry
Spring	Sixth Term Courses
Summer	Industry
Fall	Seventh Term Courses
Spring	Eighth Term Courses
(Award of B.S. degree)	
Summer	Industry

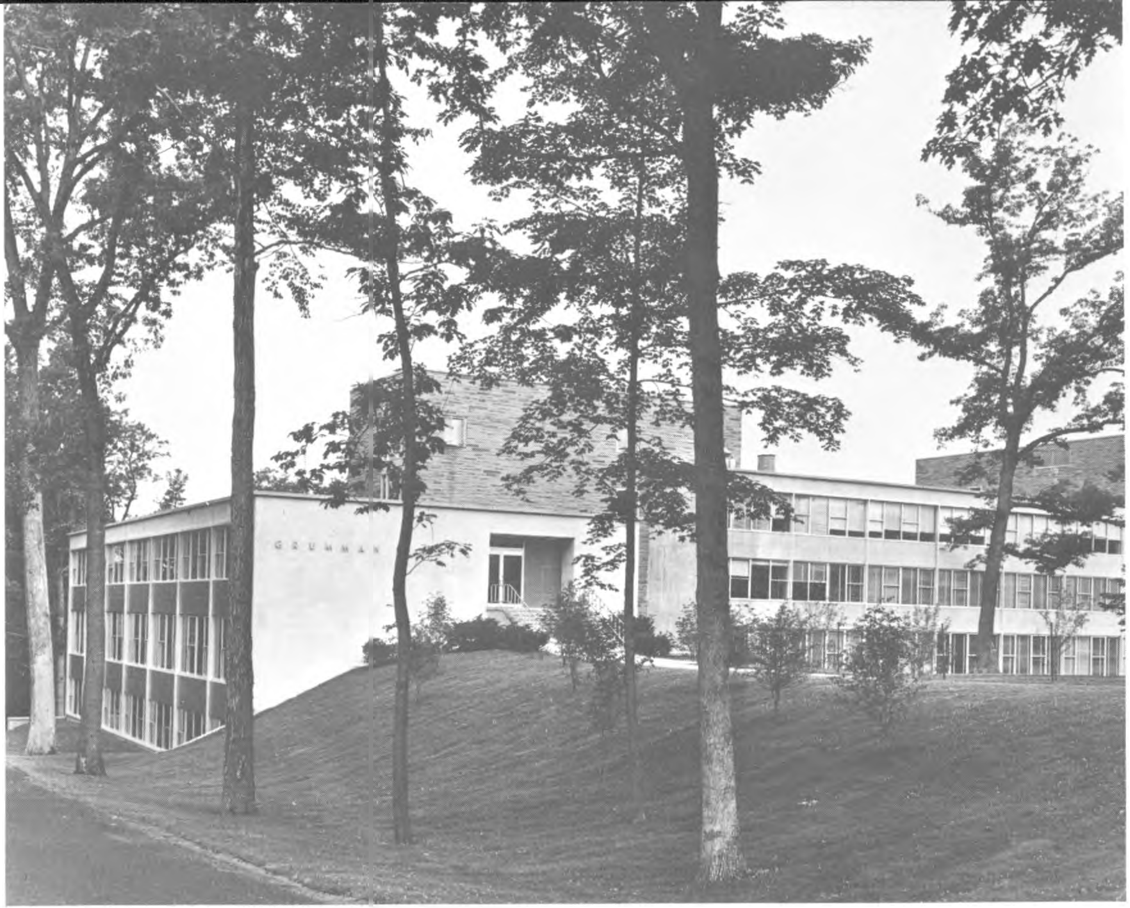
Students who seek a Master's degree are able to begin graduate study in the fall following receipt of the Bachelor's degree, just as in the regular program.

The work program of each student is arranged to advance his individual interests and aptitudes within the regular activity of the company with which he is affiliated. Because the plan visualizes progression of the student in industry from less demanding assignments through to development, research, and other more advanced responsibilities, it is not feasible for any one student to work in more than one industrial organization. He is therefore admitted to the Program by arrangement with one company and is in their employ throughout the Program. Neither the student nor the company, however, is obligated in any sense for employment beyond the completion of the Industrial Cooperative Program.

Among the industries presently participating in the Program are: American Electric Power Service Corporation, Anaconda Wire and Cable Company, Campbell Soup Company, Cornell Aeronautical Laboratory, The Emerson Electric Manufacturing Company, General Electric Company, General Radio Company, Gleason Works, Hewlett-Packard Company, Humble Oil and Refining Company, International Business Machines Corporation, Pall Corporation, and Raytheon Manufacturing Company.

Further information is available from the Industrial Cooperative Program Office, 109 Phillips Hall.

A "coop" combining his academic and industrial experience in Cornell's work-study program.



Grumman Hall houses Cornell's Graduate School of Aerospace Engineering.

AEROSPACE ENGINEERING (GRADUATE PROGRAM)

The aerospace industry — the aeronautical industry in its new setting, the space age — has been given the *systems* responsibility for such exploratory projects as satellites, space probes, and putting man into space. "*Systems* responsibility" means the entire planning and design, beginning with the basic question: How is the mission to be accomplished? Then, these questions have to be answered: What component parts and subsystems are required? What will be the size and weight? The trajectory? What power plant and guidance system will do the job?

To those questions there are no stereotyped answers. The aerospace industry may not be unique in its emphasis on new advances, but few others require such continuing concern with research and development. Engineers, physicists, and applied mathematicians are in tremendous demand. Men with mechanical engineering backgrounds are at work on power plants, electrical engineers on guidance systems, and engineers with strong backgrounds in physics and mathematics, on problems of gasdynamics, behavior of materials, and the temperature barrier. It is difficult to discern any retrenchment or leveling off.

It is the job of the Graduate School of Aerospace Engineering to educate for this exciting, research-conscious industry. To do this job means, first of all, *not* to mass-produce the traditional four-year aero engineer, a fellow who knows something about airplane performance, stability, and structural loads; today the airplane itself is part of a "system" that includes power plant, armament, guidance, ground support, etc.

The aerospace engineering graduate program provides:

1. More mathematics and physics, resumed at the point where undergraduate programs left off.

2. Emphasis on such aerospace discipline as aerodynamics, dynamics of flying vehicles, gasdynamics, plasma-dynamics, and propulsion, particularly as they apply to astronautics or space flight.

3. A research experience as members of a graduate school vigorously engaged in engineering research.

The School is investigating principles which apply to new kinds of propulsion systems for space rockets, changes in the composition of air surrounding bodies traveling at space vehicle velocities, and drag on satellites with long flight periods. Studies in magneto-fluid dynamics concern flows of electrically conducting fluids, such as ionized air, and their interaction with electromagnetic fields.

The Graduate School of Aerospace Engineering places students in a research environment and exposes them to teaching by men engaged in research. It does not try to do several other jobs simultaneously, but only to carry out this particular responsibility well. Research students get almost unlimited personal attention from their professors. Everyone reports on his research in seminars and colloquia, and, when the whole group comes together for such a purpose, it is small enough to permit informal discussion and questions.

Though the School's main concern is its graduate program, it offers excellent opportunities for undergraduate mechanical engineers, electrical engineers, and engineering physics students at Cornell. They can elect to prepare for aerospace engineering in the upperclass years and take full advantage of the School's laboratories and professors. If such students desire a graduate professional degree in aerospace engineering, they may continue their studies and obtain it in one year of graduate study.

AGRICULTURAL ENGINEERING

As the world population grows, land resources and farm population shrink. Fewer men with more equipment and larger land holdings have to produce more food on a smaller total land area. If our standard of living is to be maintained, more technical manpower will be required to help farmers attain maximum production and higher efficiency while improving the quality of their products.

In modern agriculture, the only constant is change. Consequently, the agricultural engineer must be sufficiently versed in several basic disciplines to permit problem recognition and evaluation to lead to successful application of engineering and agricultural science in the problem-solving process.

Agricultural engineers utilize basic engineering principles and a knowledge of agricultural and biological sciences to find economic applications of scientific knowledge in agricultural production and processing, specifically, by developing machinery, structures, equipment, techniques, and methods. The traditional areas of agricultural engineering are power and machinery, crop processing, rural electrification, soil and water engineering, and agricultural structures. Designations of those areas are conventionally used to indicate an individual's area of primary interest or specialization; however, the agricultural engineering curriculum includes study in all of these phases at the undergraduate level.

The course of study in agricultural engineering prepares the student to apply engineering principles to the problems of agriculture. Preparation for such work involves not only the basic knowledge of engineering principles required of

Opposite: Studying the distribution of torque in four-wheel drive systems in agricultural machinery laboratory.

ricultural science and the related engineering problems of food and fiber production met in the many industries serving agriculture. Cornell's curriculum includes five basic fields of learning:

1. Basic science: mathematics, chemistry, physics, biology.

2. Engineering science: mechanics, properties of materials, thermodynamics, fluid mechanics, electrical theory.

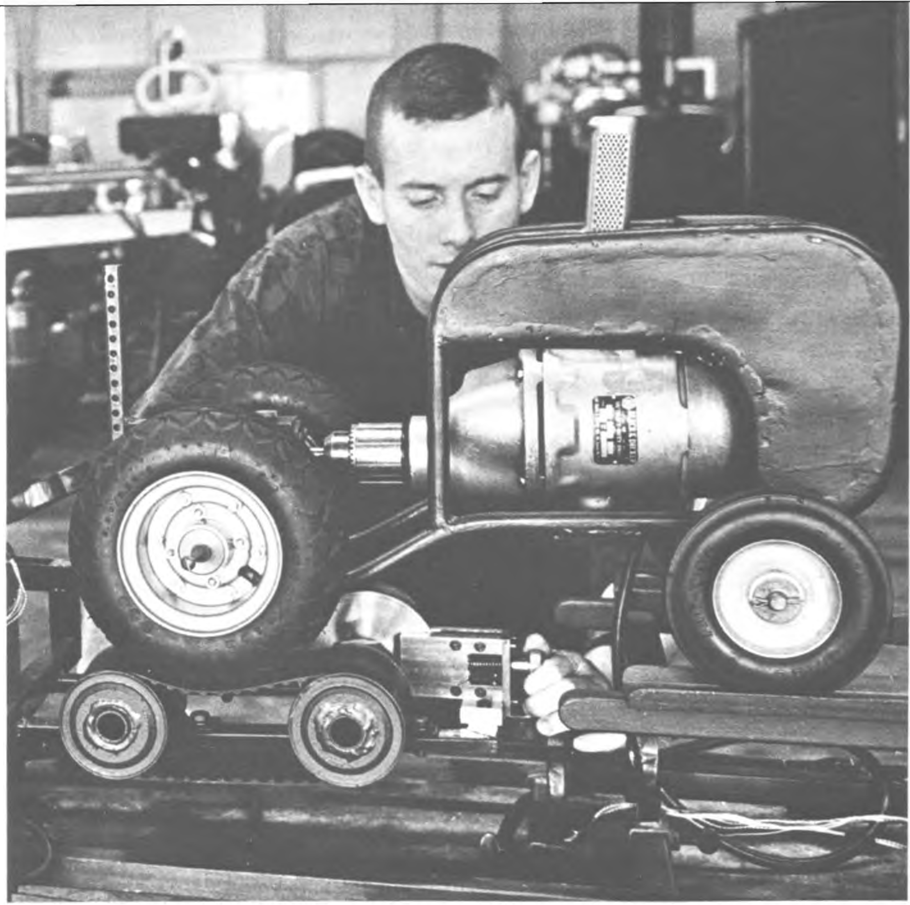
3. Engineering application: structural design, hydraulics, surveying, power units, machinery design, water control and management.

4. Agriculture: soils, field crops, livestock feeding, farm management.

5. General studies: English, social and humanistic studies, public speaking, free electives.

Students register in the College of Agriculture during the first three years, and in the fourth in the College of Engineering, which grants the degree. Throughout the undergraduate program students are advised by the agricultural engineering faculty.

Engineering principles are continually being applied to agriculture in new ways, which offer intriguing and exciting challenges. Atomic energy, solar batteries, and fuel cells are being studied as possible sources of power for the farm. Radioactive substances are used to trace the flow of nutrients in plants, to determine the wear of engine parts, and to measure the



calibration of a bench laser system.

Below: Student aligning a specimen in an X-ray camera to determine its crystal orientation.

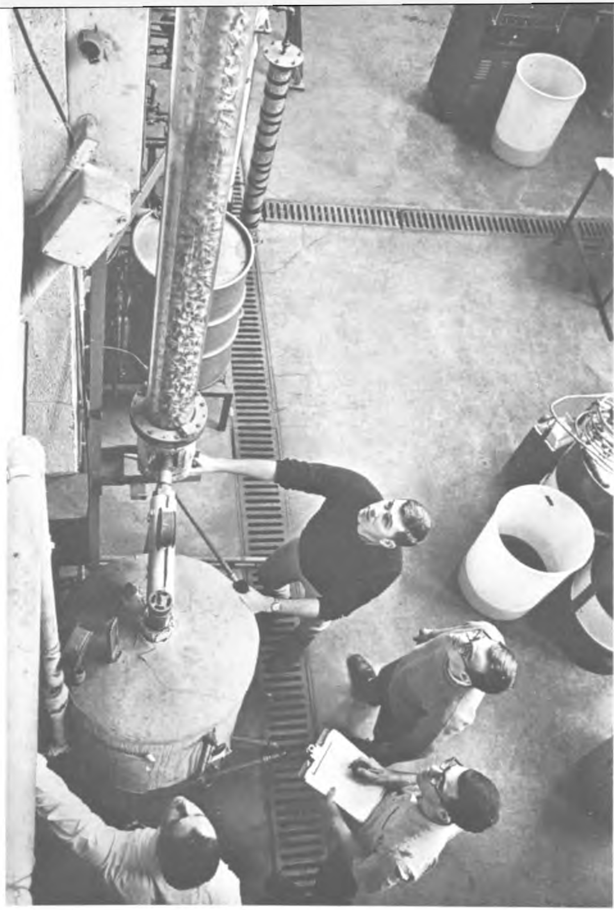
amount of moisture in the soil and the densities of materials. Electronically controlled mechanisms are being studied to obtain devices which will assure uniform loading of such machines as forage harvesters and combined harvester-threshers. Other electronic devices are being used for automation of livestock feeding. New materials are being adopted for agricultural structures. Cornell's agricultural engineering faculty is pursuing research on a wide variety of biologically oriented problems. A recent development is a mechanical grape harvester for processed grapes. The design of such a machine obviously requires a broad engineering background because of the nature of the problem — the machine and the plant are inseparable elements of the harvesting problem and the culture of the plant is paramount to the solution.

Cornell graduates are afforded unusual freedom in choice of employment as a result of their such as design of tractors and power machinery, technical sales, food processing equipment development, manufacturing, marketing, work in electric power utilities, consulting practice, teaching and research, and foreign service projects. Demand far exceeds the number of agricultural engineers available each year.

CHEMICAL ENGINEERING

Recently the chemical engineer has been deeply involved in the development of new plastics, synthetic fibers, high-energy fuels, paints, rubbers, and the reduction and use of waste materials. Jet, rocket, and atomic reactor fuels have imposed new and difficult problems still not completely solved. Disposal of atomic wastes is also an ever-increasing problem. Shortage of good water, predicted to become very severe in the near future, must be relieved by large, economical installations conceived by the chemical engineer. The world's rapidly increasing population will require more processed foods, and the problem of pollution of air and water around large population centers is rapidly becoming more urgent.

Chemical engineering is chiefly concerned with the process industries. In these industries raw materials are treated to effect a change of



Chemical engineers at work in the unit operations laboratory studying the dynamic behavior of a packed column.

state or of energy content, or a chemical conversion, to make useful products. The chemical engineer traditionally supplies engineers in other fields with new materials and structures. The electrical engineer relies on rubber and plastics for insulation, without which most electrical equipment could not exist. Such metals as titanium, zirconium, and tantalum, produced by chemical processes, give promise of major changes in structures and machines. Fuels for rockets and space vehicles are also products of chemical plants, as are the fuels which supply atomic reactors.

Chemical engineering has always been closely associated with chemistry, and undergraduates take the same courses as chemistry majors. If they elect an advanced chemistry course, they may complete the minimum chemistry requirements for a chemistry major, making it possible to go on to graduate work in pure chemistry. For research chemists working in industry, this is frequently an ideal combination, since they are trained in the economical and applied aspects of the science, as well as the theoretical.

Courses are offered in the design and operation of processing plants, and in associated problems of economic evaluation and new product development. Students learn about the varied dimensions of chemical engineering, including petroleum refining, polymeric materials, nuclear engineering, properties of materials, and food processing. Sequences of advanced courses can be elected in biochemical engineering, plastics, rubbers, reaction kinetics, and process instrumentation and automation. There are a large unit operations laboratory and 25 small project rooms; in addition, several of these fields have their own specialized laboratories.

Among present chemical engineering research projects at Cornell are the reclaiming of sea

Plant layout and design are a cornerstone activity for students in the chemical engineering curriculum. This student is putting the finishing touches on his chemical plant model.

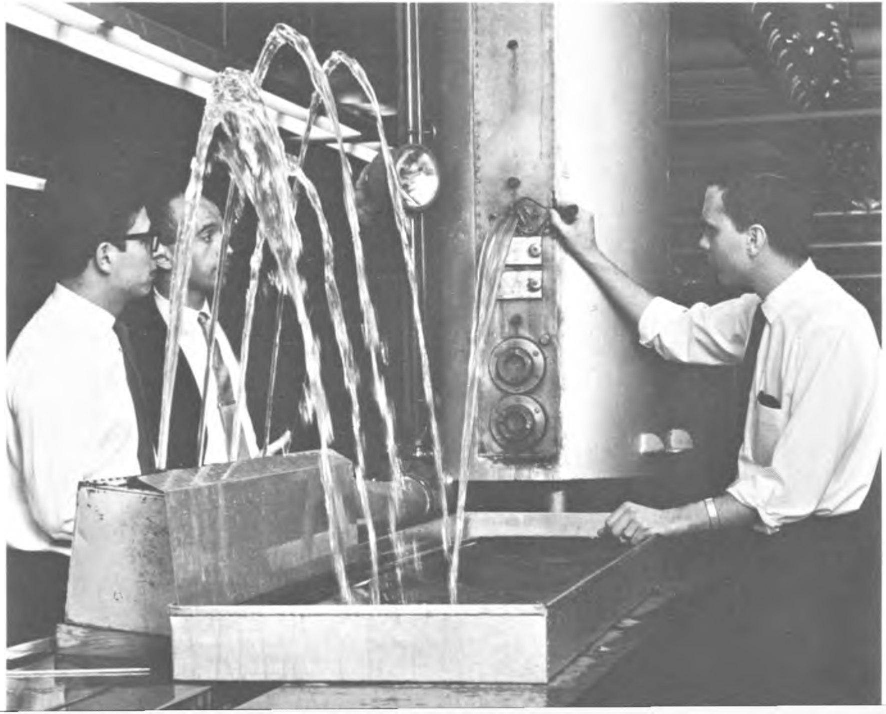
water by a freezing process, and improvement of the efficiency of pulsed columns in transferring a solute from one liquid phase to another for purification and recovery. Investigations of continuous fermentation, agitation, and aeration are being carried out in the biochemical engineering laboratory. Several projects on insulating compounds, fillers, and reinforcing agents are under way in the Geer Laboratory for Rubber and Plastics.

Graduates find employment in research, development, operation, design, and administration of processes and process plants. They are frequently required to make economic evaluations of both existing and proposed processes and developments. This type of work quickly develops administrative skills. As a result, a large proportion of chemical engineers are found in managerial positions at a relatively early age.

CIVIL ENGINEERING

Most of the world is still underdeveloped. Also, much that is developed is inadequate and outdated. Today men are required who have the vision to foresee society's needs, and the imagination and technical competence to devise ways and means to satisfy them — not only within a limited time, but with due regard to the social, economic, and aesthetic aspects involved.

Civil engineers experimenting with the dynamic behavior of jet streams as part of the study of hydraulics.



In serving such needs civil engineering touches many of our daily activities, the roads and highways we travel, the buildings in which we live and work, and the water from the tap are there largely as the products of civil engineering. The navigation and flood control systems, drainage and waste disposal systems, highway and airline transportation networks, and irrigation systems for food production will continue to be among the great contributions of civil engineering to the world's rising tide of population.

The profession demands men who are expert in one or more subfields. It also requires expert generalists who can coordinate the work of other engineers and non-engineers into team efforts. No two civil engineering projects are alike. Each must be tailored to suit a particular site and set of conditions, and each involves men of many different occupations. Usually the work of the civil engineer impinges directly on the well-being of people — a few, or a community, or a nation.

To perform such duties, the civil engineer must have a sound basis in mathematics, science, and engineering technology; in addition, he should also have a good general education in order to communicate effectively with the many other professionals and non-professionals with whom he must work. The scope of civil engineering varies from research and development to broad planning, technical design, construction, operation, maintenance, applications and sales, analysis and testing, and administration and management. Civil engineers must be familiar with scientific tools developed by men in other disciplines so they can use them in solving their problems.

After a student has completed the two-year basic studies program he takes courses in each of the major subfields of civil engineering — surveying, hydraulics, sanitary engineering, soils, transportation, structures, construction, and administration. Those courses help him determine his primary interests and aptitudes, and enable him to handle elementary problems in each area. He may then concentrate on one subfield or take further work in all areas. He may include courses in other divisions of the University, such as geological sciences, business and public administration, or city and regional planning, as well as in a broad range of liberal studies.

Instruction is vitalized by the School's continuous research programs. They include:

Photogrammetry.

Interpretation of terrestrial conditions from aerial photographs.

Strengths and deformation of soils.

Pile foundation phenomena.

Frost action in soils.

Movement of groundwater and stabilization of soil by electro-osmosis.

The flow of liquids and slurries in pipes and open channels.

Discussing problems in structures, one of many specialized activities in Civil Engineering.

Getting zeroed in to take experimental data on a basic microwave model of X-ray crystallography.

The use of systems analysis in water resource studies and sanitary engineering.

The design and behavior of bituminous concretes.

Traffic analysis.

New structural forms and materials which combine high strength and light weight.

Thin-shell structures.

The strength of structural connections.

The fundamental concepts of fracture in reinforced concrete.

Civil engineers have a wide choice of employment both at home and abroad. Some conduct their own consulting and construction firms. Others work for industries and utilities. Many serve important functions in government and in the military service. Some go into teaching. Not only does the civil engineer have variety; he also has the opportunity to achieve the inner satisfaction that comes from creativity and from solutions to challenging problems which contribute to the well-being of his fellow man.

ELECTRICAL ENGINEERING

Electrical engineering is in the forefront of some of the most exciting developments in modern science and technology. It deals with the production, control, and use of electricity, the most flexible form of energy available to man. The electrical engineer makes use of a background in both electrical science and creative design to discover, build, and promote a broad spectrum of electrical devices and systems.

Research in electrical engineering runs a gamut of activity from the exploitation of properties of materials for new devices to the synthesis of complex systems using the devices. The electrical engineer in research must be able to apply basic laws of physics and mathematics in working out principles governing both design and behavior of new devices and systems. In development, he must know and be able to apply these principles to produce working models, and he must have the capacity to visualize practical solutions and to exercise good engineering judgment. In other activities, electrical engineers are concerned with production, sales, and management. This work also requires an understanding of basic principles in both science and design.

Cornell's undergraduate curriculum in electrical engineering is sufficiently flexible so that a student can tailor his own program to emphasize any of the types of activity described. This can be done by the proper choice of electives which build upon a core of required courses in the fundamentals of engineering, physics, and mathematics. A student may choose courses dealing with systems theory, computers and servo control theory, radio and television systems, microwaves, vacuum tubes, transistors, lasers and mission networks, high voltage phenomena, electromagnetic propagation, radio astronomy, illumination, and plasma physics.

The facilities of the School of Electrical Engineering are extensive and include laboratories in quantum electronics, physical electronics, electric energy research, plasmas, microwaves, computers, communications, and antennas. In addition, there is a senior project laboratory in which students can construct and test electronic

Design of analog computer systems, part of laboratory studies in electrical engineering.

apparatus of their own design. Many of the facilities are used by undergraduates as well as by graduate students and professors for research, which promotes an ideal interaction among undergraduates and graduates.

Work is being done on microwave tubes, aimed at improving their efficiency and band width. Studies involving gaseous and solid-state lasers are concerned with basic quantum-electronic phenomena. Research on microwave plasmas relates to new means for amplifying and processing microwave signals as well as to the discovery of fundamental phenomena. A recent achievement of electronics research has been the production of extremely high electron emission currents from surfaces heated by radiation from high-power lasers.

The School of Electrical Engineering at Cornell was among the first to recognize a need for education and research in systems theory. This discipline includes network, information, communication, and control and computer theories. The research in this area includes the study of linear time-varying systems, self-optimizing detection schemes, and electronically controlled communications systems. These research programs are all based upon the design of signals and networks to meet desired performance criteria. Many of these studies include the use of the digital computer for system simulation and evaluation.

A student setting up a gaseous laser research experiment in Phillips Hall.

Opposite: The nuclear magnetic resonance laboratory where students study structural defects in materials.

Below: Investigating the behavior of an ionized mercury vapor tube.

This research has resulted in a significant contribution involving a new description of linear time-varying systems. Among other resulting achievements were the design of an electronically tunable, wide-band oscillator and several schemes for pulse expansion and compression. Such schemes are important in radar and jam-proof communication systems.

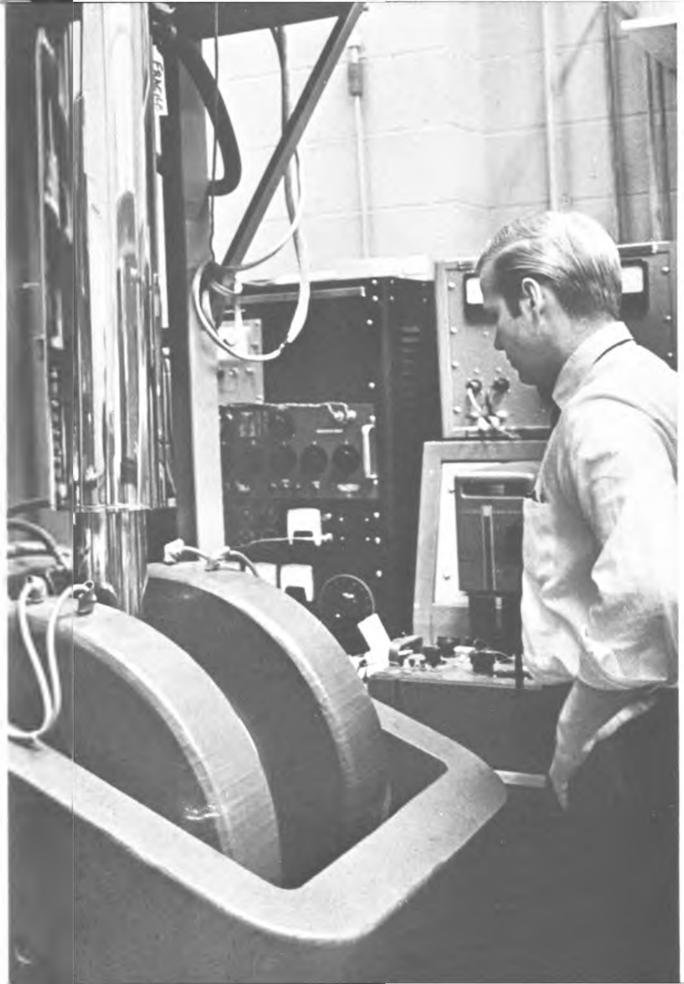
The Electric Energy Research Program is being conducted with the facilities of an extensive new laboratory equipped to handle the large power requirements of experimental plasma and arc physics. Theoretical work in plasma physics is being actively pursued to study the instabilities associated with very high temperature plasma. Other research is being conducted in semi-conductors and in underground cables.

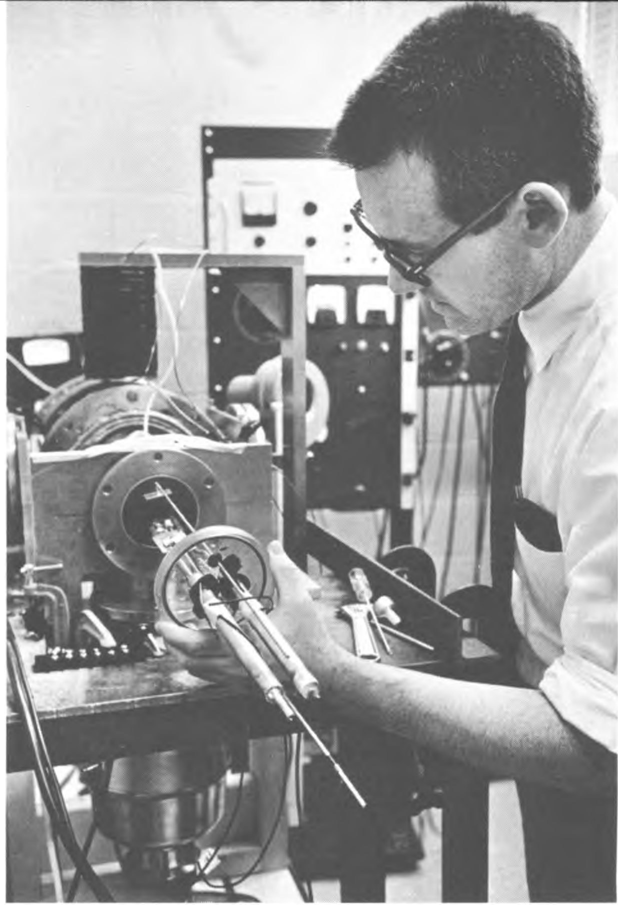
At Cornell, emphasis is placed on properly combining the essential ingredients of modern electrical engineering — electrical science and creative design. The student is limited only by his own desire and curiosity in exploring the many opportunities which are available to him.

Such opportunities are waiting in industry, government, and the academic field. Indeed, the electrical engineer has been called the indispensable man because his services are required for extensive and varied applications ranging from communications and travel on earth to similar applications in space.

The advances in many engineering fields are going to come primarily from people well trained in basic physics and mathematics, who also have considerable experience in applying the principles of these sciences to engineering technologies. What, technically, the next quarter of a century will bring, is beyond imagination. But the man solidly and broadly trained will be in a position to meet, use, and understand the new and unexpected, and, in fact, to precipitate it.

Cornell's curriculum in engineering physics provides the type of education and training which effectively bridges the gap between basic sciences and conventional engineering practice. The growth of research programs in industry, government, and educational institutions has created an increasing need for persons with such training. Cornell's program puts major emphasis on mathematics and physics. It develops understanding of the properties of materials, all the way from their constituent atoms and molecules to their bulk physical, electrical, and chemical properties. A faculty made up of members from several science departments of the College of Arts and Sciences, as well as from several of the engineering divisions, manifests the Department's emphasis on new directions which cut across traditional lines. This training enables engineering physicists to solve new types of fun-





Examining the temperature and pressure effects on structure of substances in a materials laboratory.

damental engineering problems which may be the basis for major technological advances with far-reaching consequences.

The four-year curriculum leading to the Bachelor of Science degree with a major in engineering physics gives the student a thorough understanding of the basic sciences underlying engineering applications; thus in his later studies or as a part of his professional career he may specialize in a wide variety of areas of applied physics or modern engineering such as geophysics, lasers, plasmas, space sciences, astrophysics, and the like. The engineering physics student is also eligible to continue his studies at Cornell University for another year, obtaining a Master of Engineering degree at the end of that time. In this fifth year a number of sequences of advanced courses are available. For example, the program in nuclear technology provides the sequence in reactor physics, nuclear measurements, thermonuclear power principles, advanced heat transfer, and the physics of solids underlying radiation damage. Out of such a program can come projects in atomic and nuclear physics, reactor technology, or nuclear instrumentation.

Cornell's interdisciplinary Materials Science Center concentrates studies in a field which can hold the key to further technological progress in any branch of engineering. Course sequences can prepare for projects in electron optics and electron microscopy, surface structure and reactions, defects in crystals, and other aspects of solid state physics. Several faculty members have strong research interests in space science and technology, including gasdynamics, radio wave propagation, astronomy, relativity, and related subjects. Advanced course work in aerospace engineering can lead to projects connected with various aspects of space flight.

Students in engineering physics are welcomed in the fully equipped laboratories in electron microscopy, solid state and surface physics, and nuclear technology. In their project studies students also have access to other engineering laboratories. They can also use laboratories in the University's various science departments.

The computer forms an integral ingredient of all engineering programs. Important use is made of computer techniques in the industrial engineering and administration program.

INDUSTRIAL ENGINEERING AND OPERATIONS RESEARCH

Industrial engineering, defined in part as "the design, improvement, or installation of integrated systems of men, materials, and equipment," has had a place in engineering at Cornell since 1904 as part of the School of Mechanical Engineering. In 1962, however, it was given identification as a discipline distinct from the other branches of engineering. There have been rapid developments in mathematics, especially in probability, statistics, and the computer sciences in the period following World War II; also many developments emerged from research efforts dealing with operational problems during the war. For these reasons, industrial engineering, which had been largely qualitative and empirical, has given way to "new" industrial engineering founded on quantitative bases with more sophisticated methods of analysis and design. The underlying "science" which supports this activity can be identified as the "science" of operations. When dealing with management decision problems only, it is often called "management science"; with engineering problems requiring design of facilities, it is either "industrial engineering" (within industry) or merely "systems engineering" in many other environments; and the advanced work to discover new knowledge concerning operational phenomena is simply "operations research."

The curriculum has a strong foundation in mathematics and statistical sciences. In addition, because of the complexities of systems the engineer will encounter, and the resulting computational, data collection, and processing problems, sound training in computer sciences and technology is essential. From this basis, engineering analysis and design courses have been developed to provide insight into the application of these techniques to systems problems and their use in the development of relevant models. Models are used to describe particular systems and to perform experiments with them. Courses dealing with operating problems and the decision process have also been developed. Concurrently, through elective courses, the relevant social sciences can be studied in the College of Arts and Sciences.

A system of interest to industrial engineers can perhaps be distinguished from one of interest to other engineers by three characteristics: (1) the emphasis and importance of men in the system; (2) the looseness of coupling between components of the system and the great variance of response; (3) and the action in the system which tends to be discrete, rather than continuous.

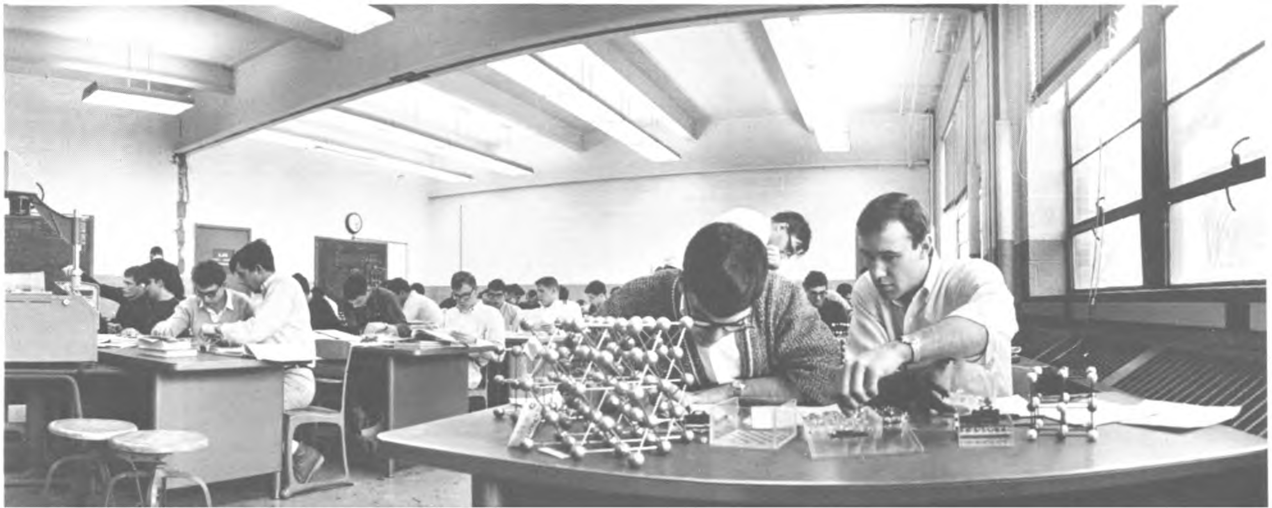
Consider queuing systems which have in common the characteristic that there is a facility providing a service to a sequence of arriving customers. Such customers compete for the service of the facility, and the balance between capacity and demand typically is such that interference situations or delays in providing the desired service are frequent. Some examples of queuing systems include airport and airplanes, maintenance man and production machines, telephone system and subscribers, toll booths on expressways and traffic, supermarket checkout counter and customers, and machines and jobs in a manufacturing shop.

The performance of a queuing system may be studied abstractly, without direct consideration of the actual objects which act as customers and as service facilities. Results obtained from such a study — the knowledge of how the system behaves analytically — are then applied by the industrial engineer in the design of an appropriate service facility, or in the specification of an operating discipline for a facility already in existence.

Inventory systems are also of interest to industrial engineers. In such cases a "commodity" is stocked in anticipation of a demand whose magnitude is not completely known at the time the stocking decision must be made. Seats on an airplane, processing capacity of a manufacturing plant, and the life of a machine tool can each be considered a form of inventory. Costs of securing and holding inventories and the level of customer service provided are performance parameters which are used in creating models for ultimate inventory system design.

Optimization is implied in any industrial engineering model analysis, and there is now some theoretical basis for many major design decisions. Today many industrial engineers work in positions with other than industrial engineering designations, for example, operations research, management science, systems analysis, operations analysis, economic analysis, and applied mathematics. They are employed in transportation, distribution, military logistics, weapons systems analysis, finance, public health, and the service industries, and as frequently in the process industries as with the mechanical manufacturing industries.

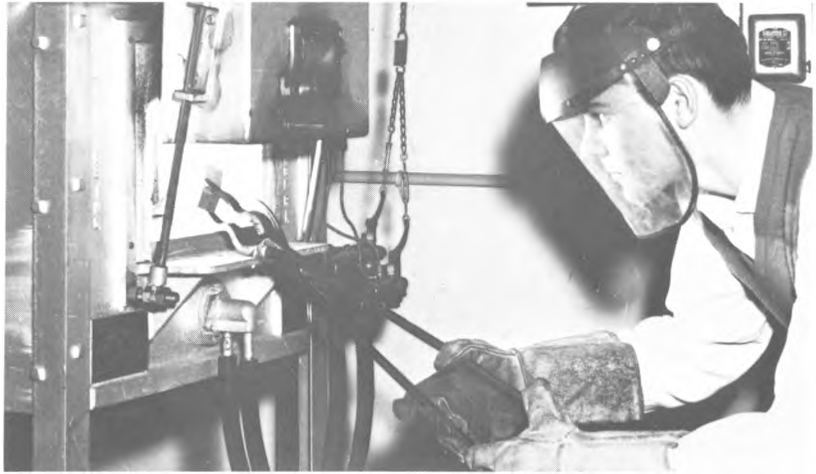
Many engineers have as an ultimate goal the desire for managerial responsibilities and positions. The types of training offered in industrial engineering provide an ideal approach for individuals with this objective not only because of the basic engineering that is included, but also because the modern trends in management science and decision-making methodology are inherent in this modern industrial engineering program.



The study of crystal and molecular structure leads to a better understanding of the properties of materials.

Right: The electron microscope has greatly aided man to peer more closely at the infinitesimally small.

Below: Placing a prepared materials sample into a thermal furnace.



Metallurgical engineers may before long be referred to not by their customary title, but by the title "materials engineers." In this era of nose cones, rocket motors, and nuclear reactors, familiar metals are not always adequate. For applications where metals used to be taken for granted as the only feasible material, ceramics, polymers, and other non-metals are coming more and more into use. The discovering and developing of new materials, metallic and non-metallic, has become one of today's most urgent engineering problems.

Cornell's Materials Science Center, recently established, is an example of this trend. It provides advanced modern facilities for materials research and brings together solid-state physicists, chemists, and engineering scientists in the field of metallurgy and materials to enhance research and graduate training. The Department of Materials Science and Engineering is in Bard Hall, an entirely new and fully equipped building.

Students in this department may receive training in materials science and technology in their upperclass years by electing courses in advanced physical chemistry, electronic structure, ceramics, alloy steels, high-temperature materials, nuclear materials, foundry engineering, polymeric materials, and advanced microscopy.

The strong emphasis on both physics and chemistry throughout the curriculum itself uniquely qualifies the student in the rapidly expanding materials science field, since the underlying principles essential to understanding metals serve equally well for an understanding of materials generally. As a result, graduates are in demand in connection with developments of many new types of materials. An outstanding example has been the contribution to the development of semi-conducting materials useful for electrical and thermoelectrical devices.

After laying a firm foundation in basic and engineering sciences, materials science and engineering students develop a theoretical and a practical understanding of all aspects of this field. Training is both broad and deep. Physical metallurgy, the branch most closely related to materials science, is based upon the physics of internal structure as it affects metallic properties. There is instruction in mechanical metallurgy; here principles of physics and engineering mechanics are applied to processing and shaping metals to obtain useful products, and students learn of the behavior of the materials under stress in airborne devices, in chemical process plants, and in machine parts. Students also learn the principles underlying the preparation of materials.

Since metals play an important part in almost every kind of engineering activity, graduates have an unexcelled diversity of opportunities for employment. They may find positions in the basic metallurgical industries, advanced engineering and research, or technical sales. Industries which fabricate and consume metals, such as the automobile, aircraft, chemical, and electronics industries, are dependent on metallurgical engineers for proper selection and utilization of metals.

Opportunities are also excellent in nuclear engineering. There are many challenging materials problems concerned with manufacture of fuel elements and reactor vessels, as well as with piping, heat exchangers, and more conventional parts. The developing aerospace industry is making very heavy demands on the supply and quality of materials engineers and scientists as well.

MECHANICAL ENGINEERING

Mechanical engineers are concerned with energy, with machinery, and with manufacture. Many are directly involved in developing or designing machinery which will transform heat, fluid flow, electricity, nuclear or solar energy, or the force of gravity, into usable power. Or, they supervise and control manufacture of the necessary machines and equipment. Some are concerned with the application and sale of machinery, still others supervise its operation. Because their activities are closely related to profits, many mechanical engineers eventually assume high management posts.

Mechanical engineers often work with scientists and engineers of other fields. It is the job of the mechanical engineer to take a device or system which has been proposed and proved in principle; to design it into an assembly of real components; to analyze and improve critical mechanical features; to make cost analyses; and to follow the parts through production: in other words, to design and produce the "hardware."

This means, for instance, starting with such fundamentals as the principles of heat transfer and power generation, and evolving conventional and nuclear power plants; steam and gas turbines; reciprocating and jet and rocket engines; or devices for heating, refrigerating, and air conditioning. One of today's most pressing problems is how to design engines which can use solid and liquid propellants to drive space vehicles.

The design of strong and durable machine parts can be an extremely important part of a whole system. In the reliability of a missile, for instance, most failures are due to fracture vibration, wear, or leakage; or to looseness or binding from thermal expansion or dimensional inaccuracies. The mechanical engineer can anticipate and prevent such troubles by design and control of product quality.

Varying the condition of the fluid medium in the thermal engineering laboratory.

Right: Observing a "strip chart" recorder's results on a fluid mechanics experiment in mechanical engineering.

Because new products, new machines, new methods, and new sources of energy are continually being required or discovered, it is not sufficient that the mechanical engineer be familiar with the existing store of knowledge in a particular field. Thus he is constantly engaged in research to obtain new design data, both for known systems and for new systems which are continually being conceived. Whatever may develop in the future in the practical application of new physical and chemical phenomena, mechanical engineers will be in at the early stages of experimentation, as they are now in thermoelectric power and solar energy. Also, new mechanical developments occur continually in established industries.

Below: A group of mechanical engineers working on a senior research project dealing with heat transfer through turbulent fluids.

Of all groups of engineers, mechanical engineers are employed in the widest range of industries; therefore it is difficult to limit and describe the opportunities available to them. Companies in the chemical process field, the electrical field, the construction field, and others, as well as the wide-spread mechanical field, all hire mechanical engineers. In fact, the greatest demand by industry as a whole for any single group is for mechanical engineers.

The function in industry that the young engineer will perform depends on his interests and capabilities, and the specific needs of his employer. The breadth of his education, however, is apt to lead rapidly to management responsibilities if he has the necessary personal qualifications.

The elective requirements of the mechanical engineering curriculum offer many attractive possibilities. The student may devote these electives to a special field of interest within mechanical engineering, such as thermal engineering, design and development, or materials processing. Or, if he wishes, he may expand his background in industrial engineering, electrical engineering, mechanics, or materials engineering. The required program of courses in mechanical engineering, supplemented by a carefully planned elective program, assures a student of a solid base for future growth and development in his chosen career.

NUCLEAR ENGINEERING (GRADUATE PROGRAM)

Today, the rapidly expanding international nuclear industry is made up of nearly 2000 corporations providing nuclear equipment and services. Over seventy nuclear power stations are in operation or under construction around the world. The United States itself has eleven in operation, representing over one thousand megawatts of installed capacity, and has generated over sixteen billion kilowatt hours of nuclear electricity. By the year 2000, the Atomic Energy Commission estimates that nuclear power plants will account for over half of the electricity generated.

Other exciting but less widespread applications of nuclear phenomena are also pursued by graduates trained in this field.

To become a leader in this rapidly expanding technology, where specific applications learned today are often obsolete five years hence, a student must be able to assimilate new developments in the basic sciences, recognize their significance for engineering problems, and initiate the technical realization of the solutions he proposes. Graduate study can most effectively contribute to these objectives by emphasizing the attainment of new knoweldge through experimental and theoretical research.

Since the backgrounds and interests of the students vary widely, the detailed program of studies in nuclear engineering is not prescribed in a rigid pattern. The ideal preparation for admission to graduate work in nuclear engineering is an undergraduate major with a strong background in mathematics and modern physics. This can be accomplished through a major in engineering science, physics, chemistry, mathematics, or one of the engineering fields.

The choice of minor subjects depends on the student's background and interests. A student with an undergraduate major in engineering is usually expected to choose one minor in a basic science, and vice versa. The student majoring in nuclear engineering is expected to have a sound background in such subjects as fluid flow and heat transfer, which he can develop as a minor subject if he does not already have this background from his undergraduate work.

Research in nuclear engineering is intended not only to extend knowledge but to apply it to engineering objectives. Topics may be chosen from among these subjects: reactor statics of slightly enriched, water-moderated critical assemblies and subcritical assemblies, reactor kinetics, nuclear materials and fuels, chemonuclear processes, basic processes in the transfer of heat and generation of power from nuclear reactions, and selected problems in reactor design and optimization.

Work involving nuclear phenomena, radiation, isotope production, and the like is done for the most part in the Nuclear Reactor Laboratory. Among its facilities are a TRIGA reactor, a "zero power" reactor, gamma irradiation cell, and a newly installed Cockroft Walton accelerator.

A student of unusual ability, who is not yet ready to take courses on the graduate level, may be admitted to the program. Such a student may start with advanced undergraduate courses with the understanding that he will require more time to complete his degree program.

THEORETICAL AND APPLIED MECHANICS

A thick-walled bathyscaph exploring the ocean depths, a nuclear container protecting man from danger, a thin-walled flying pressure vessel (a rocket) on a distant space adventure — all these are designed by using the same principles. Engineers realize such achievements by a process of conception, analysis, experiment, and development. Applying fundamental principles in each part of this process, they reach out in new directions to strange and unknown environments. The art and applications may vary from industry to industry, and the different branches of engineering often appear distinct. But the principles are the same, and therefore engineering education is focusing on the common aspects underlying the entire engineering profession.

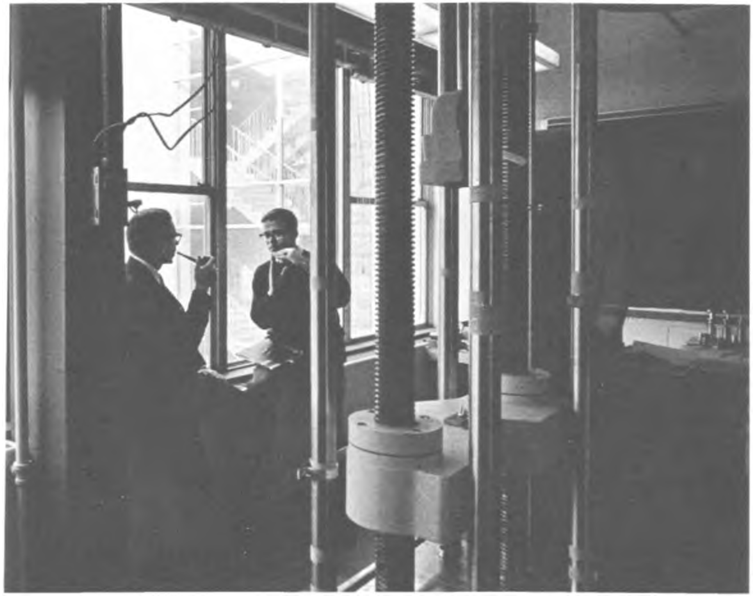
Every engineer must acquire proficiency in both applied mechanics and applied mathematics. Cornell's Department of Theoretical and Applied Mechanics is responsible for undergraduate instruction in these two sciences and is engaged in vigorous graduate and research programs. Professors with varied scientific and engineering backgrounds exchange ideas and plan educational programs. They are studying the mathematical principles of the perceptron, a machine which can memorize symbols and patterns and then identify them. Professors and graduate students are investigating the dynamic loading of machine parts, and the behavior of materials and physical laws under pressures thousands of times that of the atmosphere. Analysis of elastic wave propagation is being applied to studies of movements within the earth. Also being studied are the fundamental mechanisms of cracking in concrete, the trajectories and orbits of space vehicles and satellites, and the static and dynamic behavior of thin-walled structures in unknown environments.

In their first years all engineering undergraduates take applied mathematics and applied mechanics. Here they learn the fundamentals which underlie later courses in structures, machine design, engineering analysis, fluid flow, and materials. Applied mathematics introduces new methods of analysis, emphasizing the derivation of mathematical expressions for engineering problems. Applied mechanics involves the theory of statics, strength of materials, and dynamics.

Undergraduate students who wish to pursue such topics more deeply can elect advanced courses in vibration theory, crystal mechanics, or theoretical and experimental stress analysis. Or, they can study numerical methods in engineering analysis, orbit theory, and other subjects which bear on many of the unsolved problems at the horizon of technology. Elective course sequences, coupled with a project, make possible an effective start toward graduate work.

Because of excellent laboratory facilities, studies can range from the microscopic to the full-size static and dynamic testing of structures under actual operating conditions. Undergraduates use their laboratory experience in course work and in their projects.

Graduates who have elected to work in applied mechanics and mathematics have before them a wide choice of job opportunities. Persons deeply rooted in fundamentals, who have analytical skill, are in continuous and great demnad. They are sought by long-established industries and by newer industries whose existence depends on research and development. Students frequently pursue graduate work, which leads to research and development careers in industry or universities, or to careers in technical management.



A spring morning on one corner of the engineering campus. Upson Hall is in the background.

The new engineering complex is a symbol of Cornell's pioneering and preparation for the future, and of Cornell engineering graduates' leadership in all fields of industry and research. Ten modern, spacious buildings bring teaching and research together in fourteen acres of floor space and house the finest of equipment. In addition to the laboratories where students themselves work on almost every conceivable type of engineering device and instrument, there are separate small laboratories where they can conduct independent work. Such small laboratories, used most often by upperclassmen working on projects and by graduate students, are serviced by shops where equipment can be constructed.

Complementing these engineering facilities is a new physical sciences building, Clark Hall. Taking into account the modernization and additional construction for the physics and chemistry facilities, nearly twenty million dollars is being spent on strengthening the University's resources in the physical sciences.

BARD HALL OF METALLURGICAL ENGINEERING

Gift of Francis N. Bard '04, former owner and president of Barco Manufacturing Company.

A major portion of Bard Hall is designed for both instruction and research. It is a six-story building, containing approximately 45,000 square feet of floor space.

A large high-ceiling area is available for equipment for processing both metallic and non-metallic materials. A complex of laboratories for structural characterization of materials is included, with equipment for optical microscopy, electron microscopy, and X-ray diffraction and other methods for investigating the structure of materials, with separate facilities for undergraduate instruction and graduate research. Facilities for physical metallurgy and mechanical metallurgy have been provided, as well as equipment for general metallurgy.

Study of radioactive materials and the use of radioactive tracer materials as a research tool have necessitated special facilities within the building for the safe handling of such materials.

CARPENTER HALL, ENGINEERING LIBRARY AND ADMINISTRATION

Gift of Walter S. Carpenter '10, Chairman of the Board of E.I. du Pont de Nemours and Company.

Carpenter Hall contains about 50,000 square feet of floor area in two floors and basement. The first floor is devoted to a large main reading room, a browsing room, a microfilm room, and

Bard Hall is the home of the College's laboratories and faculty in materials and metallurgy.

spacious table areas for study and problem work, and easily accessible book and periodical shelves. Special attention has been given to natural and artificial lighting and to acoustical treatment. Access to the main stacks is also provided from the reading room, to encourage student use of the stacks. Main stacks give a capacity of some 75,000 volumes and also include 72 open study carrels. Total stack space provides for approximately 160,000 volumes.

The central area of the second floor serves as a second general reading room. A corridor from this room leads to a series of individual studies which are assigned to persons engaged in library projects extending over a period of time.

The browsing room near the main reading room is named for Albert W. Smith, Director and Dean of Sibley College of Mechanical Engineering, 1904-21 — the period just prior to the combining of the separate Colleges of Civil Engineering and Mechanical Engineering into a single College of Engineering. Dean Smith, still affectionately "Uncle Pete" in the memory of many alumni, championed the development of broad cultural interests among his students. The room named as a memorial to him contains a growing collection of books reflecting his purpose. As a contemporary extension, a considerable portion of the collection includes works that will develop among engineering students an appreciation of tion, and motivations, and of the consequent challenge to them as engineers and as citizens.

Administrative offices of the College of Engineering are located along the north and east side of the second floor. The offices of the Dean and administrative staff, and a conference room, extend from a central reception area. A second suite of offices is assigned to various student services, including admissions, scholarships, and placement. The placement area contains a large collection of company and career material, and include individual placement interview rooms.

AEROSPACE ENGINEERING

Gift of Leroy R. Grumman '16, Chairman of the Board, Grumman Aircraft Corporation.

Grumman Hall's laboratories and machinery provide crucial work space and equipment for research in such vital areas as aerodynamics, gasdynamics, and propulsion of aircraft and space vehicles. Shock tubes simulate flows at flight Mach numbers of 20 and greater, making possible the study of heating and re-entry problems for missiles and satellites.

The Albert W. Smith browsing library in Carpenter Hall, a place to relax between study periods in the technical sections of the library.

Looking through the arch of Myron Taylor Hall, Cornell's Law School, toward Hollister Hall, center for civil engineering activities.

A large and diversified shock tube facility makes research possible with many gases so that high temperature reaction rates may be studied comprehensively. Investigations in the field of magneto-gasdynamics, both basic and applied, are being conducted through Grumman Hall's facilities.

The building stands three stories high and is attached to Upson Hall, the School of Mechanical Engineering, to make possible joint activities.

HOLLISTER HALL OF CIVIL ENGINEERING

Gift of Spencer T. Olin '21, director and member of the executive board, Olin Mathieson Chemical Corporation, in memory of his father, Franklin W. Olin '86, and named in honor of Solomon Cady Hollister, Dean of the College of Engineering, 1937-59.

Evaluations and studies prepared by the Civil Engineering faculty were incorporated in the development of the building to meet future requirements of the School.

Facilities for comprehensive instruction in hydraulics and fluid mechanics are on the lower floor of Hollister Hall. Also on this floor are the transportation laboratory for instruction and research in highway and airport design, associated construction methods, and traffic control problems and a machine shop for the construction of apparatus used in research and instruction.

The several laboratories for sanitary engineering are on the two floors just above the hydraulic laboratory. Facilities are provided for filtration column investigations, radio-isotype tracer studies, and measurements of environmental radioactivity. Special surveying laboratories and plotting rooms are available for instruction in new aerial photogrammetric procedures.

Investigations of the strength, deformation, and hydraulic properties of soils are carried out in the soil mechanics laboratory. Modern equipment is available for use in the solution of both applied and research problems. The structural models laboratory, with facilities for both instruction and research, is one of the most modern and well-equipped in the country. Among the many significant studies under way are several on the development of materials and techniques for the use of small-scale models in reinforced concrete research. A large testing laboratory, located in nearby Thurston Hall, is used for general structural research. Experimental work having a major impact on design methods and procedures in both steel and concrete has been conducted in these laboratories.

Housed on the top floor of Hollister Hall is the Cornell Center for Aerial Photographic Studies. This Center maintains an expanding collection of over 80,000 photographs showing soil, rock drainage, vegetation, and other clues needed to determine the suitability for man's works, of sites all over the world. Aerial photo interpretation and physical environmental evaluation are tools used by the engineer planner in all climates and for all areas be they arid or humid, arctic or tropical. Continued research is being carried on by the Center on such projects as the growth of cities, sources of materials for construction, tropical soils, location of transportation facilities, and the like.

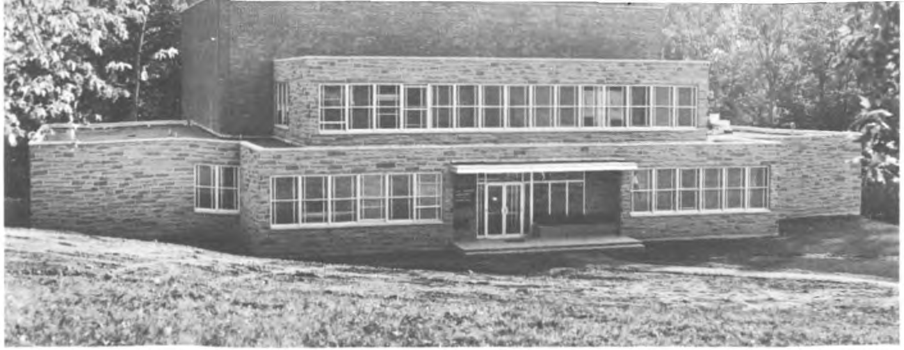
KIMBALL HALL OF MATERIALS PROCESSING

Kimball Hall was named in honor of the late Dexter S. Kimball, Dean of the College of Engineering, 1920-36.

The main room of approximately 5,600 square feet houses a selection of production-type machine tools, including turret lathes, automatic bar and chucking machines, and gear cutting machines.

Two unique test beds are available for research and machine testing. They are concrete slabs isolated from the building proper, resting on vibration absorbing pads above the bedrock. This facility is used for both graduate and undergraduate instruction.

A specially constructed constant (68° F.) temperature room allows for gage calibration and precise measurement. A large number of gages



The Nuclear Reactor Laboratory contains an unusually broad range of facilities for instruction and research in nuclear engineering for both undergraduates and graduate students

are available, including pneumatic, electronic, and optical types.

Kimball Hall also houses the undergratuate laboratories where basic studies are being made on metal cutting, tool forces, chip formation, and power consumption. Other equipment permits studies in surface texture, statistical quality control as well as process planning, tooling, and capabilities.

NUCLEAR REACTOR LABORATORY

The laboratory is the result of the cooperative efforts of many individuals and organizations, with financial assistance from the Atomic Energy Commission, the National Science Foundation, and the Cornell Aeronautical Laboratory.

The Triga Reactor* is the largest and most versatile of the three specialized nuclear facilities in the Laboratory. It can be operated at steady power levels up to 100 kilowatts. Because of the unique fuel design, it can also be operated so as to deliver its power (and radiation) in pulses reaching a peak of 250 megawatts and lasting several hundredths of a second. Research in many interesting new topics is made feasible by use of the pulsing mode of operation.

The Zero Power Reactor, in which the pattern and number of fuel elements can be easily changed for experimental purposes, is designed specifically for reactor physics experimentation. Because at higher power levels the radioactivity of the fuel elements and structure, even during shutdown, would hamper manipulation of the fuel elements, the ZPR is intentionally limited to ten watts maximum power and is therefore not primarily a source of neutrons or isotopes. The reactor physics teaching and research experiments made possible by the ZPR include, for example, measurements of temperature coefficients of reactivity, critical approaches, and reactor spectrum studies.

The third specialized facility in the Laboratory is the gamma cell, which is a small cubical room shielded by thick concrete walls. Sealed radioactive sources of up to 10,000 curies strength may be safely used within it. Four deep floor wells with removable plugs are used for source storage. A remotely operated crane, two master-slave mechanical arms, and a three and one-half foot thick glass viewing window permit remote manipulation of the sources; a thick steel door provides access to the cell when the sources are in storage. Research areas utilizing the gamma cell include radiation effects on materials and on chemical reactions.

OLIN HALL OF CHEMICAL ENGINEERING

Gift of the late Franklin W. Olin '86, founder of Olin Mathieson Chemical Corporation and Olin Industries Incorporated, in memory of his son, Franklin Walter Olin, Jr. '12.

One unusual feature in Olin Hall is the provision of twenty-five small student laboratories, where small groups can work together on problems of common interest. There is also a unit operations laboratory extending through three stories which houses, and in which can be constructed, semi-plant-scale equipment for both instruction and research. Laboratory space for the constructing of pilot plants for study of actual scale operation, allowing accurate estimates of the performance of full-size commercial plants, is available. The Geer Laboratory offers facilities for the study of polymeric materials.

Olin Hall provides laboratory facilities for chemical engineers.

PHILLIPS HALL OF ELECTRICAL ENGINEERING

Electrical Engineering laboratories and research facilities are located in Phillips Hall.

Phillips Hall is the gift of Ellis L. Phillips, '95, founder of E. L. Phillips and Company, and organizer of numerous gas and electric companies. This structure provides unsurpassed physical resources for teaching and research in the School of Electrical Engineering. Laboratories for areas such as communications, servomechanisms, power and machinery, basic electrical measurements, digital and analog computers, microwave and solid-state electronics, and quantum electronics, provide a unique range of facilities and flexibility.

The various laboratories provide specialized facilities for undergraduate laboratory space and equipment, infra-red and visible light measurements, secondary electrical standards, an antenna range for radio-wave measurements, and high-vacuum processing, there is also a clean chemical room for solid-state materials processing and device fabrication. All of the laboratories at the undergraduate as well as the graduate research levels are well equipped with a wide assortment of electronic instrumentation. In laboratory design, departures from the conventional are evident throughout. Power distribution within the building is handled by flexible control boards which enable any combination of requirements to be drawn for any room.

RILEY-ROBB HALL OF AGRICULTURAL ENGINEERING

Named in honor of Professor Howard Wait Riley, former Head of the Department of Agricultural Engineering; and in honor of the late Byron Burnett Robb, Professor of Agricultural

Engineering and also former Head of the Department. Riley-Robb is located at the eastern edge of Alumni Field on the upper campus.

Laboratories are equipped with facilities for teaching and research in the fields of power and machinery, structures, soil and water engineering, electrification, and the processing and handling of agricultural products.

THURSTON HALL OF THEORETICAL AND APPLIED MECHANICS

Named in honor of the late Robert Henry Thurston, Director of the Sibley College of Mechanical Engineering, 1885-1903.

Special features of Thurston Hall are a dynamic photoelastic laboratory, an applied mechanics laboratory, a dynamics laboratory, and individual research laboratories for graduate work.

Thurston Hall includes a specially constructed wing approximately 60 ft. wide x 65 ft. deep x 50 ft. high, which is a test cell in itself. Anchorages and buttresses are included as an integral part of this unique structure and permit loading from all directions and at all points of the cell. Weighing capsules are movable so that an entire structure may be tested at full scale. In this cell it is possible to test assembled bridges, structural frames, and small complete buildings. Loading can be both dynamic and static.

UPSON HALL OF MECHANICAL ENGINEERING

Gift of Maxwell M. Upson '99, Chairman of the Board, Raymond International, Incorporated.

Upson Hall enjoys an unusual natural setting. It faces Cascadilla Gorge to the south so that its two wings embrace a grove of tall trees on a knoll above the gorge. The interior construction features standard classrooms which can be used interchangeably for lecture, recitation, or computing. Small rooms are provided for assignment to upperclassmen and graduate students for individual or group projects.

A substantial portion of the building is designed as laboratory space for both instruction and research. Major laboratories include a large two-story engineering laboratory and associated rooms—the modern form of the time-honored "mech lab" so familiar to Cornell engineers—which houses the equipment for work in heat transfer, fuels, combustion, power, refrigeration, and related fields. Other laboratories are devoted to machine design, vibration studies, dynamic analysis, and lubrication.

The Department of Industrial Engineering and Operations Research, also housed in Upson Hall, has laboratory facilities for the study of work measurement, methods engineering, plant layout, materials handling, and other aspects of production engineering.

A Sunday afternoon "Pop Concert" on the Library slope.

Perhaps the best way to describe the extracurricular opportunities on the campus is to say that there is literally something to interest everyone among the great variety of organizations, clubs, publications, athletic programs, and hobbies. One may well ask, since engineering is so rigorous, whether there is really time to take advantage of all Cornell's extracurricular opportunities? Of all, no. Of some, yes. In some respects, this works to the advantage of the engineering student, for limiting himself enables him to direct his enthusiasm and energy with greater intensity and greater rewards.

Freshmen spend about twenty-five hours a week in classes and in laboratories. Another twenty-five to thirty hours is required for class assignments and further individual study. That adds up to between fifty and fifty-five hours a week for academic work alone. This pattern remains about the same during all four years: the level of courses rises at about the same rate as a student's ability to handle it.

In general, an engineering freshman ought to allow himself one evening and one day a week (Saturday night and Sunday, for instance) for recreation and entertainment. Unless he cannot avoid it, he ought to forego part-time employment during his first year, while he is getting accustomed to his course and college life. The way to the most expanded education, scholastic and extracurricular, is discipline—not discipline commanded by someone else, but discipline imposed by one's self so as to be able to begin, execute, and conclude a task well.

In recent years, for example, Cornell engineers have been presidents of many campus organizations, including the Executive Committee of the Student Government, the student center in Willard Straight Hall, Cornell United Religious Work, the Freshman Class, the Navy ROTC Brigade, and Sphinx Head, the senior honor society. Engineering students make up the second largest number of varsity athletes in the University. They have always played leading parts in Cornell's many music organizations.

For freshmen, thoughtful planning, especially during the first weeks, is the key to entering athletics or an activity. Though they must restrict themselves during their first year, they ought to be able to take part in athletics or some one student organization without too much difficulty.

RELIGIOUS ACTIVITIES

Although Cornell has been a nonsectarian institution from its founding, it has a center for the coordination and sponsorship of religious activities. Anabel Taylor Hall, the headquarters for Cornell United Religious Work, includes

Left: *A church service in Anabel Taylor Hall chapel, center of the Cornell United Religious Work program.*

Right: After services in Sage Chapel.

a staff of twelve University chaplains representing the major religious traditions, and a director and his associates. CURW's thirteen religious groups, as well as students who have no specific religious affiliation, meet for inquiry, study, worship, counsel, and fellowship. Anabel Taylor Hall has an interfaith chapel and is the center of the One World Club, a large group of American and international students. In addition, each Sunday distinguished visiting clergymen from throughout the world conduct interdenominational services in Sage Chapel. Ithaca churches welcome Cornellians to their congregations and offer programs of particular interest to them.

ATHLETICS

With the largest intercollegiate athletic program in the country, including twenty-two sports,

Crew, one of many sports in which Cornell enjoys a national reputation.

anyone can go out for intercollegiate teams, and he doesn't have to be an expert. In fact in some sports, many students become varsity members after having played for the first time at Cornell.

As a member of the Ivy League, Cornell participates in its organized associations in football, hockey, soccer, basketball, wrestling, fencing, lacrosse, and squash, and is a member of the Eastern Intercollegiate associations in golf, swimming, 150-pound football, rowing, baseball, and the Heptagonal Games in track and cross country. Also on the intercollegiate program are polo, rifle, and sailing. Archery, cricket, rugby, and skiing are conducted on an informal basis.

But this is only a small part of the athletic program. Everybody always seems to be playing *something* — not only intramurals, in which leagues are going throughout the year, but innumerable pickup games and matches. Students can get instruction in individual sports such as swimming, tennis, and squash, or in golf on Cornell's 18-hole course. One of Cornell's aims is to give students a chance to learn and take part in sports that can be carried on after college.

Cornell's forty-eight acres of playing fields are almost all on campus or within walking distance, with tennis courts in various locations. Teagle Hall has two swimming pools, a gymnasium, and rooms for wrestling, fencing, boxing, rowing, and exercises. Varsity and intramural basketball,


BROWN
COLUMBIA
CORNELL
YALE

wrestling, and indoor track, including the Heptagonal Games, take place in Barton Hall, the huge armory, which also has a rifle and pistol range. Lynah Hall is for hockey and skating, and the Grumman Squash Courts have facilities for six teams. The Riding Hall is the scene of polo matches and instruction in horsemanship, and Bacon Cage has indoor baseball and track practice, and instruction in golf. Off campus, Moakley House and Collyer Boat House serve golf and crew. Schoellkopf Field is the home of the Big Red football team.

This uncommonly well conceived and superbly equipped plant is given maximum usage. Over 2,000 men come out for the intercollegiate teams each year, and about 4,000 take part in the 78 intramural leagues, which play 2,300 contests during the school year.

LECTURES, CONCERTS, AND THE ARTS

The College of Engineering, as part of a large and educationally diverse University, is able to offer its students a broad spectrum of lectures covering all topics of human interest and concern. During the past year, Cornell's Latin American Year, students were privileged to hear a number of distinguished visitors from south of the border, including Radomiro Tomic, Chilean Ambassador to the U. S., and Juscelino Kubitschek,

Opposite: The Heptagonal Track Meet is held annually at Cornell's Barton Hall, featuring all the Ivy League teams plus Army and Navy.

Above: Action on Hoy Field's diamond.

Left: Basketball is one of many winter sports on the Cornell calendar.

former President of Brazil. Octavio Paz, Mexican Ambassador to India, widely known poet and social critic, was also on campus as Visiting Professor of Linguistics during the spring term.

Among other visiting lecturers heard during 1965-66 were Theodore Sorenson, former Special Counsel to the late President John F. Kennedy; Dr. A. Frey-Wyssling, Swiss Federal Institute of Technology, Zurich; W. H. Ferry of the Center for Study of Democratic Institutions, Santa Barbara; Dr. W. A. Visser 't Hooft, General Secretary of the World Council of Churches; and Charles Singleton, Professor of Humanistic Studies at Johns Hopkins University.

An exhibition area in the Andrew Dickson White Museum, where permanent and traveling art exhibits are displayed.

The Department of Music sponsors three concert series which bring to Cornell noted artists from both here and abroad. Several campus musical and dramatic groups present programs in Bailey Hall, the University Theatre, Sage Chapel, Alice Statler Auditorium, the Drummond Studio, Anabel Taylor Hall, and Barnes Hall. Among outstanding guest presentations of the past season were touring productions of the Erik Hawkins Dance Company; the New York City Opera Company in *Carmen* and *The Barber of Seville*; and Judith Rutherford Marechal's dramatic presentation, *In White America*.

The Andrew Dickson White Museum of Art contains the University's collection of paintings, prints, and sculpture, plus several areas devoted to special traveling exhibits. Visiting artists on campus for the Latin American Year included Manuel Felguerez, Mexican sculptor, and Ernesto Deira, Argentine painter. The student center in Willard Straight Hall sponsors creative art exhibits, often the work of students, operates a music room, and has a collection of phonograph records which may be used by a student in his own residence.

With Cornell's large number of international students, numbering over a thousand, visits to the campus by cosmopolitan persons and groups are frequent; this provides opportunities for Cornell students to become better acquainted with the cultures of more remote corners of the world.

Goldwin Smith Hall.

SOCIETIES, CLUBS, AND STUDENT ORGANIZATIONS

For the many students interested in music, Cornell offers ample opportunity to join one of a number of groups. The University Glee Club presents concerts on campus, and on tour to such countries as Russia and England. In the spring term of 1966, the Glee Club, under the direction of Thomas Sokol, presented over twenty-five concerts in Ceylon, Thailand, Singapore, Malaysia, the Philippines, Hong Kong, Taiwan, Okinawa, Korea, and Japan. In addition, they have joined with the Philadelphia Orchestra in concerts in both Philadelphia and Ithaca. Every Sunday, the Sage Chapel Choir sings at services conducted in Sage Chapel.

The hundred-square Big Red Band, one of the nation's renowned college bands, makes fifty appearances a year, and two Concert Bands give symphonic concerts on campus — indoors during the winter months and outdoors during spring. Other musical clubs put on and sponsor musical comedies, jazz, Gilbert and Sullivan, and folk songs.

The Debate Association, a member of the Ivy League Debate Conference, engages in nearly one hundred intercollegiate debates annually, highlighted by one with a British university. Each year the Cornell Dramatic Club presents in the University Theatre six major productions of

Opposite: The Engineering Student Council is responsible for a broad range of student activities, including the annual Cornell Day.

Left: On stage, a student performance of Julius Caesar.

traditional, modern, and original plays. These, as well as some twenty-five Drummond Studio Workshop productions, offer an opportunity to those who want to try a hand at acting, lighting, stagecraft, costuming, or directing.

A strong voice in University affairs is the Cornell Daily Sun, a full-scale daily newspaper freely operated by students. The *Sun* carries world, national, and University news. Students also publish a yearbook, the *Cornellian,* and several literary and humor magazines. Of particular interest to the engineer seeking experience on a student publication is the *Cornell Engineer,* one of the finest undergraduate engineering magazines in the country. The *Engineer* not only offers opportunities for editing, business management, and technical writing, but provides acquaintance with action "behind the scenes" in the College.

There are international and political clubs, service clubs, professional and departmental societies, and clubs devoted to almost anyone's hobby. Student announcers and technicians of the Cornell Radio Guild staff and operate the campus station, WVBR. Radio hams of the Cornell Amateur Radio Club have a well-equipped radio shack and workshop, own an amateur radio station, and operate a public address system. Cayuga Lake provides excellent sailing for the fleet of the Cornell Corinthian Yacht Club. The Photo Club has full darkroom facilities. The Outing Club not only takes advantage of Cornell's surroundings for hiking, skating, and skiing, but plans mountain climbing trips to the Adirondacks, the Green Mountains, and even Canada. Other clubs bring together those interested in skiing, polo, rifle and pistol, chess, cricket, folk dancing, and many other activities.

A large number of these clubs and organizations are centered in Willard Straight Hall. "The Straight" includes several dining rooms and cafeterias, the University Theatre, an arts and crafts workshop, game rooms, and a browsing library. Included in its facilities are guest rooms for visiting parents and friends.

Soaking up the sun on the Willard Straight Hall terrace.

Cornell is situated in one of the major outdoor recreational centers of the East. For the outdoor enthusiasts, there are three outstanding state parks, all within a fifteen-minute drive from the campus, which offer swimming, picnicking, hiking, and recreational sports. Taughannock Falls State Park, on Cayuga Lake, includes a 215-foot waterfall, the highest east of the Rockies. Cayuga Lake itself provides excellent boating conditions, and the University boat house is located conveniently on an inlet feeding into the lake.

In the spring Beebe Lake offers an opportunity for canoeing or swimming on campus, and in winter for outdoor skating. For the increasing number of ski enthusiasts among the student body, Greek Peak, approximately fifteen miles away, offers fine skiing for beginners or experts. Cornell's gorges and streams never cease to be fascinating. For those who prefer just relaxing, the Library Slope has grass, shade, a magnificent view of Cayuga Lake, and occasional outdoor band concerts. There are movies downtown and on campus, plays, concerts, a variety of dances and parties, and all kinds of intercollegiate athletic events. Astronomy enthusiasts can visit Fuertes Observatory, and bird lovers, the famous Sapsucker Woods.

There are always things going on, planned and spontaneous, for large groups and small.

SPECIAL STUDENT SERVICES

ADVISING AND COUNSELING

To aid the transition from high school to college and from home life to individual responsibility, all Cornell freshmen take part in the University's orientation program the week before classes begin. The program is designed to acquaint the freshman student with the campus facilities and to provide an opportunity for him to meet informally with members of the engineering faculty.

In general, freshmen are assigned an adviser from one of the engineering fields in which a particular interest has been indicated. The advisers are concerned with their students as students, as future engineers, and as persons.

Students are free to consult with the Dean, directors, and other faculty members on any educational or personal matter. In addition, the University's Dean of Students and his staff assist students with any non-academic problems.

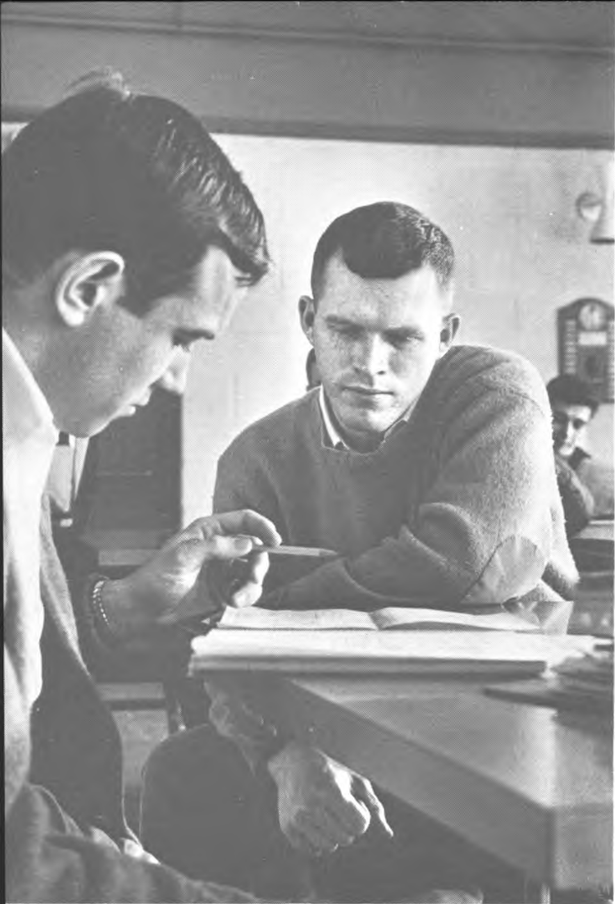
PROFESSIONAL GUIDANCE AND PLACEMENT

Engineering students have particularly good opportunities to discover what is going on in the engineering profession and where their interests may lie. In addition to faculty and advisers, students learn much about their professional area through participation in their student chapters of the various professional societies such as the American Institute of Chemical Engineers, American Institute of Industrial Engineers, American Society of Civil Engineers, and American Society of Mechanical Engineers. National and local honor societies — Tau Beta Pi, Phi Kappa Phi, Sigma Xi, Pi Tau Sigma, Chi Epsilon, Rod and Bob-Pyramid, Atmos, Kappa Tau Chi, and Eta Kappa Nu — also function in the College of Engineering.

To help students obtain professional employment, the Student Personnel Office of the College works with the University Placement Service in the arrangement of interviews with prospective employers, and in the maintenance of student records. There is no charge to the student for this service. Traditionally Cornell engineers have been eagerly sought by corporations, both large and small, and usually can select from several offers.

One notable fact is the frequency with which Cornell engineers move into leadership responsibilities in both technical and administrative areas. This is due in part to the nature of engineering education at Cornell, and to the tradition of education for leadership. The University community fosters a personal development which makes the transition from University education to career responsibilities easier and richer in opportunity.

OFFICER EDUCATION



The ROTC programs (Army, Navy, and Air Force) offer a college student the opportunity to fulfill his military commitment as a commissioned officer. To obtain a commission in one of the services, a student must complete a two-year or a four-year course of study in an ROTC program and must meet certain physical standards. Upon graduation he receives a commission and, commencing within one year after graduation, serves a required tour of active military service.

Participation in any of the ROTC programs (Army, Navy, and Air Force) at Cornell is *voluntary*. While the decision is obviously a personal matter, students are encouraged to consult with their school advisers, counselors, and local draft boards.

Further information is given in the *Announcement of Officer Education,* which may be obtained by writing to Cornell University Announcements, Day Hall.

PHYSICAL EDUCATION AND HEALTH SERVICES

All freshmen and sophomores are required to take physical education. The program, which for freshmen changes every six weeks, includes basketball, golf, tennis, volleyball, wrestling, and

Informal conversation between classes in one of the several student lounges located in the engineering buildings.

swimming. Sophomores concentrate on one or two sports which they can continue during their upperclass years and after graduation. In addition to a complete intercollegiate program, the University sponsors and directs a very active intramural program in which a majority of the upperclassmen participate.

Complete health services are available at Cornell's Gannett Medical Clinic and Sage Hospital (a fully accredited hospital). Student fees cover treatment and care at the Clinic and Hospital, with up to two weeks of hospitalization per term.

A Cornell score on Lynah Hall's rink.

SCHOLASTIC BACKGROUND AND SPECIAL SKILLS

Applicants will be admitted to the College of Engineering who in all essential respects have demonstrated a high order of scholastic achievement and who, so far as can be determined, have a well considered desire to study engineering. In addition, they must possess positive characteristics of work and study and the maturity which will be necessary to meet the demands of living successfully in a complex and demanding university environment. Good grades or high College Board scores are in themselves no guarantees of success or even of admission. A strong motivation and the determination to achieve are important. The inducements and the opportunities to combine constructive extracurricular experiences with a rigorous and exacting academic program require sound health, balanced judgment, and confidence.

The specific scholastic requriements for admission are listed below. A statement of the reasons for them will give them more meaning.

Mathematics is of course a primary tool of the engineer, but too few high school students realize that competence in English is equally important. The engineer communicates basically in two languages, English and mathematics; if he lacks skill in either, his success as a student in engineering college will be impaired. Thus, for the prospective student, the perfection of skills in reading, writing, and speaking should be of principal concern, and English, history, and social studies courses are a means to this end.

Two years of a foreign language are required; it is hoped that the prospective student will have studied one for three or four years. As more engineering students go on to graduate school and prepare for research careers, the need to know other languages increases, and those who study for Ph.D. degrees must have a working knowledge of two foreign languages, preferably German, Russian, or French. Unless the start on this requirement is made in high school, time must grudgingly be spent learning languages at the height of one's professional training.

A love for mathematics becomes increasingly a hallmark of the engineer. Some aspect of applied mathematics will characterize almost every course in engineering college, noticeably so in the first two years. Not only is it imperative that you have a natural aptitude for mathematics as demonstrated by school grades and test scores; you must have the faculty of thinking in mathematical terms and liking it. At the very least, you will be expected to have mastered mathematics up to, but not including, calculus; advanced placement is readily available for the increasing number who can demonstrate their progress beyond this level.

The courses in chemistry and physics are not

only a test of your skills in science, but even more a challenge to your interests. Modern engineering demands a deep penetration into scientific theory, and fully half the engineering curriculum will involve increasing study and use of the physical sciences. Hence these subjects should be "naturals" for you.

The Basic Studies program (freshman and sophomore years) will test your powers of analysis, involving theory and abstraction. If high school has prepared you adequately, and if you possess this skill, you will be off to a good start.

REQUIREMENTS FOR ADMISSION

Sixteen units* of college preparatory subjects are required. The following fourteen units must be included:

English	4 units
History	2 units
One foreign language	2 units
Algebra (elementary and intermediate)	2 units
Plane geometry	1 unit
Trigonometry	½ unit
Advanced algebra or solid geometry	½ unit
Chemistry	1 unit
Physics	1 unit

*A unit is one year of study, made up of 120 hours of classroom work; that is, a minimum of 160 class periods if each is forty-five minutes long.

Left: Heading down "Libe" slope to the men's residence halls.

Below: A view of one corner of the men's dormitory area.

It is recommended that the applicant offer advanced algebra, if possible, and that the elective units offered be in further study in language or history. The mathematics units listed above may be taken as separate courses or may be included within four units of comprehensive college preparatory mathematics. The Scholastic Aptitude Test of the College Entrance Examination Board is required.

All applicants must take the College Board achievement tests in mathematics and in chemistry or physics. The Level I achievement test in mathematics is required of *all* applicants and must be taken not later than January of the senior year. The Level II test (if offered) may

A spring class on the Arts quad.

be taken *in addition* by applicants who wish placement in advanced sections of the first calculus course. Applicants seeking advanced placement for college credit should take the mathematics advanced placement examination in May of the senior year.

Applicants should take the achievement test in chemistry or physics in May of the junior year or in December or January of the senior year, provided they have completed one year of study in the subject in the junior year.

HOW TO APPLY

Detailed information about requirements for admission and procedures is given in the Cornell *Announcement of General Information*,* which every candidate should read carefully. It can be obtained by writing to the Cornell University Announcements Office. All correspondence concerning admission to the College of Engineering should be addressed to the Office of Admissions, Day Hall, Cornell University, Ithaca, N.Y. 14850, which will forward application blanks on

*The X-ray requirement is revised to read: "Every student is required to have a chest X-ray. He is given opportunity to satisfy the requirement in his first week on campus. The General Fee covers cost of the X-ray examination. A former student re-entering after more than a year's absence must again meet the requirement but at his own expense."

A student lounge for engineering students.

request. Places to write for further information are listed inside the back cover.

Transfer Students. Students who wish to transfer to Cornell Engineering from another college or university should write the Office of Admissions for information about applications.

LIVING ARRANGEMENTS

Most freshmen live in dormitories which are within convenient distance of academic buildings, libraries, and dining facilities. Students from the various colleges live together in the same buildings, one or two to a room. Unless they have other preferences, those who request double rooms are assigned a fellow student in the same college: it is often helpful for engineers to begin their college careers living with those taking a similar program.

On the ground floor of each of the freshman men's buildings is a large social lounge with a kitchen, and on each of the other three floors a separate lounge. In the central dormitory there is a cafeteria which serves all three meals and is open during the evening. Dormitory students can obtain their meals in various University cafeterias and dining rooms according to their own choice and schedule. Those who wish may save by prepaying for their meals for an entire semester. For women, most of the dormitories have dining facilities.

Boldt Hall, one of the men's residence halls.

Though freshman men are not required to live in dormitories, most do. About one-third of *all* Cornell men live in dormitories, one-third off campus, and one-third in fraternity houses. Rushing for fraternities and sororities takes place during the early weeks of the second term; bids are extended shortly thereafter.

FINANCIAL AID

Cornell's integrated program of scholarships, loans, and employment helps students meet the costs of college education. *Nearly a quarter of a million dollars is awarded annually by the University to engineering freshmen alone. Recently over 65 per cent of all engineering students have held scholarships or grants-in-aid, exclusive of loans.*

Scholarships are awarded for the most part to entering students whose scholastic capabilities should place them at least in the top half of their college class. Otherwise, evidence of special professional competence, constructive participation in school and community affairs, or significant work experience are factors in selection. Stipends will vary according to financial need and may range from as much as $2400 to as little as $100 for honorary awards. In most instances an applicant's financial need will be met in part by the opportunity to borrow either through the University or the National Defense Student Loan program. A descriptive list of all scholarships available to freshmen may be obtained from the Office of Scholarships and Financial Aid, Day Hall.

Financial assistance to upperclassmen who are unsuccessful in winning freshman awards is available in substantial amounts through the Office of Scholarships and Financial Aid; many students are assisted annually by grants, loans, student employment, or a combination of these resources. Few students who achieve satisfactory scholastic rank in their first year in the College find it necessary to withdraw at any time for financial reasons. Engineering students are not encouraged to undertake part-time employment in the freshman year.

University Halls are part of the living center for freshman.

FURTHER INFORMATION

All prospective students should obtain the *Announcement of General Information.* (See below.)

Engineering curricula and course descriptions:
Cornell University Announcements
Edmund Ezra Day Hall
Ithaca, New York 14850

Scholarships:
Office of Scholarships and Financial Aid
Edmund Ezra Day Hall
Ithaca, New York 14850

Admission requirements, procedures, and applications:
Office of Admissions
Edmund Ezra Day Hall
Ithaca, New York 14850

General Information and Other Announcements, listed below:
Cornell University Announcements
Edmund Ezra Day Hall
Ithaca, New York 14850

Announcements are available for other academic divisions of Cornell University as follows: State College of Agriculture, College of Architecture, College of Arts and Sciences, School of Education, International Studies, State College of Home Economics, School of Hotel Administration, State School of Industrial and Labor Relations, Officer Education, Summer Session. Graduate study is described in other Announcements as listed on the cover of the *Announcement of General Information.* (When requesting information, the writer should include his zip code.)

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