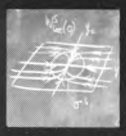
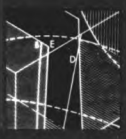
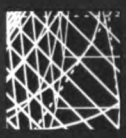
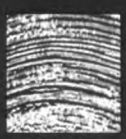
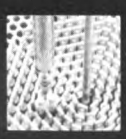




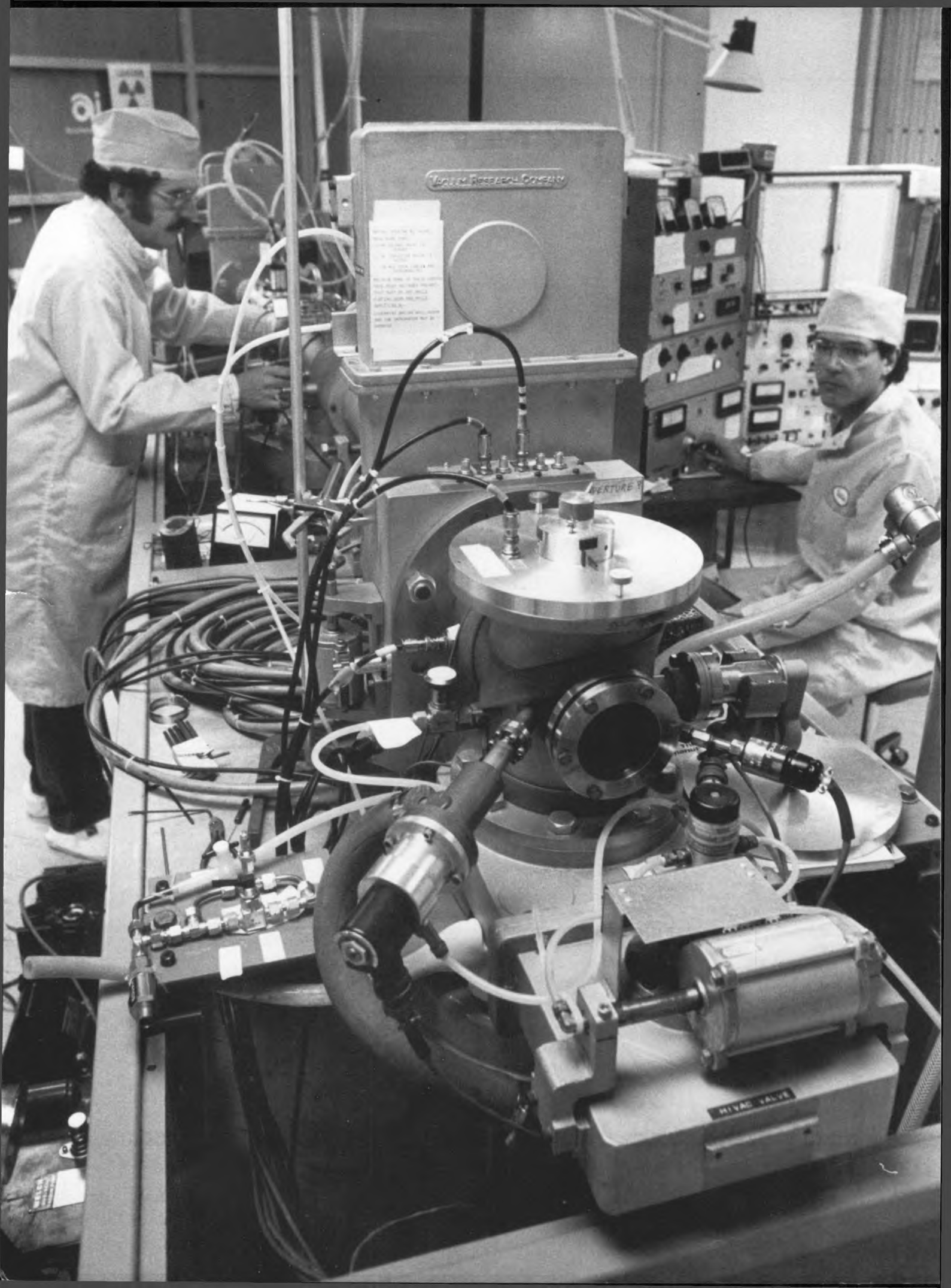



Cornell University Announcements

Graduate Study in Engineering and Applied Science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Graduate Study in Engineering and Applied Science

Cornell University
Ithaca, New York

Contents

Cornell University Announcements
(ISSN 0744-4605)

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The Programs at Cornell

At Cornell, graduate study in engineering and applied science is conducted in the context of a large and diverse university with an international reputation. Part of this reputation is as a leading research university; in engineering fields, funding for research consistently places Cornell among the top five institutions in the nation. Excellent facilities and an outstanding faculty are important components of the wealth of University resources available to every graduate student.

Since individual graduate programs are organized within fields of instruction, this Announcement is intended as an introduction to the various graduate fields in engineering and applied science. Each field is described briefly, and the professors are listed with their research interests.

The degrees offered in each area include the research-oriented Master of Science (M.S.) and Doctor of Philosophy (Ph.D.) degrees and, usually, the professional Master of Engineering (M.Eng.) degree.

In planning an M.S. or Ph.D. program, a student must first select a graduate field, since admission is determined by the faculty who are members of that field. Because the separation of graduate programs into fields is necessarily somewhat arbitrary—some areas of research are interdisciplinary and some fields draw on faculty members in related departments or areas—the information in this booklet should help in the selection. Each candidate also chooses, usually toward the beginning of residency, a Special Committee headed by the professor who will direct the thesis research. The selection of this committee, which supervises the student's entire program and progress, may also be facilitated by the information given here.

M.Eng. degrees are offered in eleven fields: aerospace, agricultural, chemical, civil and environmental, electrical, mechanical, and nuclear engineering; computer science; engineering physics; materials science; and operations research and industrial engineering. In addition, there is a curriculum in manufacturing systems that leads to a Dean's Certificate and an M.Eng. degree in one of the eleven fields. A degree in geological sciences is pending. The M.Eng. degrees entail design projects rather than thesis research and usually require one year of study. In general, the M.Eng. work is supervised by professors who are members of the corresponding graduate fields.

Graduate Enrollment and Support

The number of applicants to graduate programs in engineering and applied science has increased steadily in recent years, and there has been a moderate rise in the number enrolled. In 1984-85, admission was offered to about 31 percent of those who applied for the M.S./Ph.D. program, and about 79 percent of those who applied for the M.Eng. program. The number of graduate students is about eleven hundred and the research faculty numbers about two hundred.

Graduate students are supported by a variety of fellowships, assistantships, and stipends that are available through the Graduate School, the College, the departments, and special programs and centers. The support that can be offered to an individual is communicated to the applicant by the Graduate School. Generally the support covers tuition and fees and includes a stipend.

Facilities for Graduate Research

As one of the nation's major research universities, Cornell offers unusually extensive facilities in many areas of investigation. Some of these are mentioned here in connection with the various fields of study. Some are available for graduate research through Cornell's outstanding interdisciplinary centers.

Cornell's leadership in organizing and equipping interdisciplinary research centers is a significant factor in its attractiveness as a graduate university. Some laboratories are national facilities, offering equipment and consultation that would be unavailable under the usual university constraints. Others are supported by federal agencies or corporate groups. Centers and programs of particular interest to graduate students in engineering and the sciences are given in the accompanying list.

Important to most graduate students in engineering and applied science are the University's computing facilities. The central system includes IBM mainframe and DEC VAX systems and Floating Point Systems Array Processors. These are accessed by means of interactive terminals and graphics facilities at convenient locations on the campus. The central system also includes an IBM supercomputer, which is accessed through network nodes in various parts of the campus. College of Engineering buildings are interconnected by an Ethernet. Specialized equipment for computer-aided design is available. Many departments and research groups have computers dedicated to their research; these include IBM 4341, DEC VAX, Data General, PRIME, AT&T, and other computers of similar power, plus numerous AT&T, Hewlett-Packard, IBM, Macintosh, and other microcomputers and workstations.

Also of universal importance is the University's outstanding library, comprising more than five million volumes and a comprehensive periodical collection.

Interdisciplinary Centers, Laboratories, and Programs

Biotechnology Program

Center for Applied Mathematics

Center for Environmental Research

Center for International Studies

Center for Radiophysics and Space Research

Center for Theory and Simulation in Science and Engineering (Theory Center)

Computer-Aided Design Instructional Facility (CADIF)

Cornell High Energy Synchrotron Source (CHESS)

Cornell Laboratory for Environmental Applications of Remote Sensing (CLEARS)

Cornell Manufacturing Engineering and Productivity Program (COMEPP)

Cornell Program for the Study of the Continents (COPSTOC)

Institute for the Study of the Continents (INSTOC)

Laboratory of Plasma Studies

Materials Science Center

Mathematical Sciences Institute (MSI)

National Astronomy and Ionosphere Center (operated by Cornell in Puerto Rico)

National Research and Resource Facility for Submicron Structures (National Submicron Facility or NRRFSS)

Program of Computer Graphics

Program on Science, Technology, and Society

Semiconductor Research Corporation Program for VLSI Microscience and Technology (SRC)

Ward Laboratory of Nuclear Engineering

Funding for Research

The annual expenditures for project research in engineering and applied science at Cornell have increased in the past six years from about $11 million to more than $34.9 million (in 1984-85). According to the survey of engineering college research and graduate study that was published in 1985 in *Engineering Education,* Cornell held fifth place in total expenditures for engineering research. The annual expenditures averaged about $165,000 per faculty member.

About 77 percent of the funding for Cornell's research in engineering comes from federal agencies, with the National Science Foundation providing over half the total amount. Industry has been contributing an increasing share, however; funding from industrial sources has risen by a factor of about five in the past six years to a current level of about 14.7 percent. In addition, corporations have given valuable equipment and funds for laboratory renovation. The consensus of the faculty is that the increasing industrial support—and participation in research programs—strengthens the position of Cornell as a graduate research university.

Information for Applicants

The most important contact for a prospective M.S. or Ph.D. degree applicant is the graduate faculty representative of the field of interest. These representatives, who are identified in the following sections, will be glad to provide detailed information on the opportunities available for study and research. Students interested in one of the professional degrees may write to the associated department, school, or graduate field or to the Master of Engineering Degree Program, Cornell University, Hollister Hall, Ithaca, New York 14853-3501.

The *Announcement of the Graduate School* and *Introducing Cornell* should be consulted for information on admission, financial aid, and degree requirements, as well as general information about the University. Academic programs and courses are described in *Courses of Study.* Copies of these publications may be obtained by writing to Cornell University Announcements, Building 7, Research Park, Ithaca, New York 14850-1247.

Application materials, including financial aid information and request forms, may be obtained from the Graduate School, Cornell University, Sage Graduate Center, Ithaca, New York 14853-6201, or from a graduate faculty representative. Application materials for any of the M.Eng. programs may be obtained by writing to Graduate Professional Engineering Programs, Cornell University, Hollister Hall, Ithaca, New York 14853-1247.

Aerospace Engineering

Aerospace engineering is concerned with the flight of aircraft, missiles, and space vehicles. Classical areas are aerodynamics, control, and propulsion, but the field's frontiers are constantly expanding as new, often interdisciplinary problems are encountered. At Cornell about twenty graduate students are enrolled in programs designed to prepare them for research and advanced development in this field of rapidly changing science and technology.

Programs leading to M.S. and Ph.D. degrees are offered in the Graduate Field of Aerospace Engineering. In the curriculum, emphasis is placed upon fundamental science as well as current design practice. Students are encouraged to take courses in physics, mathematics, chemistry, astronomy, and allied engineering subjects, as well as in aerospace engineering. Courses offered in the closely related Graduate Field of Mechanical Engineering are particularly relevant, and the two fields conduct a joint weekly colloquium and joint research conferences. Graduate students often find these opportunities for discussion with faculty members and other students particularly helpful in the early phases of their research. The entire group operates as a research team, and a friendly, informal atmosphere prevails.

The M.Eng.(Aerospace) program emphasizes the application of basic science to aerospace engineering problems. Students acquire a fundamental background and become familiar with techniques that will remain useful in all modern engineering developments. Requirements for the degree, usually completed in one year, include completion of core courses in fluid mechanics, theoretical aerodynamics, or high-temperature gasdynamics; a sequence in mathematics; electives; and work on a design project.

Facilities

Experimental facilities are available for laboratory studies in fluid mechanics, aerodynamics, turbulence, gasdynamics, magnetohydrodynamics, plasma-dynamics, combustion, laser chemistry, geophysical fluid dynamics, ferrofluidics, and acoustics.

The field has a long history of pioneering work in the development of the shock tube as a research tool for the study of chemical kinetics and electrically conducting gases and for supporting studies in fusion plasmadynamics and laser chemistry. Other special facilities include wind tunnels for investigations of turbulence; of automobile, bicycle, airplane, and windmill models; and of collisionless plasmas.

Areas of Research

The research emphasis is on basic problems in fluid mechanics, aerodynamics, and combustion. Included are studies in turbulence, transonic and unsteady flows, and geophysical and atmospheric flow, as well as the development of computational techniques for analyzing these problems. Important areas of application are the dispersal and control of pollutants, aerodynamic noise generation, and turbomachinery flow problems.

Current research includes, for example, projects concerned with problems of aerodynamic noise associated with helicopter rotors, and other aerodynamic problems associated with unsteady and transonic effects; a study of turbulence and the modeling of its properties; the development of computational techniques for transonic flow problems; and the prediction of rotating stall in turbomachines. Other research activities extend to such varied subjects of study as convection cells within the earth and the moon, the possibilities of fusion power, computing techniques for fluid mechanical problems, and fluid motion and heat transfer in polymer melts.

Examples of subject areas in which M.Eng. students can do project work include pollution control for automobile engines without loss of efficiency; hydrogen and methanol internal combustion engines; vehicle aerodynamics; solar-energy collectors; controlled fusion; electric probes as combustion analyzers; wind tunnel experimentation; atmospheric flow; unsteady flow experimentation; and properties of turbulence.

Faculty Members and Their Research Interests

Peter L. Auer, A.B. (Cornell), Ph.D. (California Institute of Technology): *plasma physics, fusion power, energy policy analysis*

David A. Caughey, B.S.E. (Michigan), A.M., Ph.D. (Princeton): *fluid dynamics, transonic flow, computational aerodynamics*

P. C. Tobias de Boer, Ir.(M.E.) (Delft, the Netherlands), Ph.D. (Maryland): *combustion processes, alternative fuels for combustion engines, high-temperature gasdynamics*

Albert R. George, B.S.E., A.M., Ph.D. (Princeton): *fluid dynamics, acoustics and noise control, aerodynamics, automotive engineering*

Frederick C. Gouldin, B.S.E., Ph.D. (Princeton): *combustion, fluid dynamics, air pollution, combustion spectroscopy*

Sidney Leibovich, B.S. (California Institute of Technology), Ph.D. (Cornell): *fluid dynamics, wave propagation, air-sea interactions*

Geoffrey S. S. Ludford, B.A., M.A., Ph.D., Sc.D. (Cambridge): *fluid mechanics, magnetohydrodynamics, combustion and related applied mathematics*

John L. Lumley, B.A. (Harvard), M.S.E., Ph.D. (Johns Hopkins): *fluid dynamics, turbulence and turbulence modeling, geophysical turbulence, stochastic processes*

Franklin K. Moore, B.S., Ph.D. (Cornell): *fluid dynamics, energy systems, thermal pollution, turbomachinery*

Stephen B. Pope, B.Sc., M.Sc., Ph.D. (Imperial College, London): *combustion, turbulence, fluid mechanics, numerical methods*

Edwin L. Resler, Jr., B.S. (Notre Dame), Ph.D. (Cornell): *high-temperature gasdynamics, pollution control, ferrofluid mechanics*

Shan-Fu Shen, B.S. (National Central, China), Sc.D. (M.I.T.): *aerodynamics, computational fluid mechanics, polymer processing*

Dennis G. Shepherd, B.Sc. (Michigan): *fluid mechanics, turbomachinery, thermal and wind power*

Donald L. Turcotte, B.S. (California Institute of Technology), M.Aero.E. (Cornell), Ph.D. (California Institute of Technology): *geomechanics, geophysical fluid dynamics*

Zellman Warhaft, B.E. (Melbourne), Ph.D. (London): *experimental fluid mechanics, turbulence, micrometeorology*

Further Information

Further information may be obtained by writing to Zellman Warhaft, Graduate Faculty Representative, Aerospace Engineering, Cornell University, Upson Hall, Ithaca, New York 14853-7501.

Agricultural Engineering

The application of engineering to agriculture and the related food-production and processing industries is a broad field, and diversity of interests characterizes graduate study in the Field of Agricultural Engineering at Cornell.

More than fifty students from all regions of the United States and from several other countries are enrolled in programs leading to the degrees of M.S., M.Eng. (Agricultural), M.P.S. (Agriculture)—the Master of Professional Studies—or Ph.D. For the M.S. and Ph.D. degrees, thesis research is conducted on subjects that range from the entirely theoretical to the almost completely experimental, although most combine analytical and experimental work. The curricula draw on strong programs at Cornell in mathematics and in the physical, biological, and engineering sciences and characteristically reflect an interdisciplinary approach. The M.Eng. and M.P.S. degree programs offer advanced course work and project development rather than thesis research. The M.Eng. is a program intended to prepare students for engineering practice; the M.P.S. program emphasizes the applications of technology to agriculture.

Facilities

Major laboratories in the agricultural engineering building include those for research in agricultural-waste management, for small-animal calorimetry and environmental physiological studies, for applications of biotechnology, for electronics and computers, and for work in the controlled-atmosphere storage of agricultural materials. Numerous mini- and microcomputers are available for data processing, instrumentation development, and the control of experimental programs.

Other facilities include the nearby Agricultural Waste Management Laboratory for pilot-plant studies, the Animal Science Teaching and Research Center, plots for the study of nutrients and runoff, greenhouses, and plant-growth chambers. The University's excellent library and computing facilities contribute to the quality and effectiveness of the graduate programs.

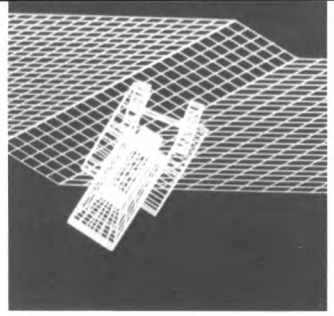
Areas of Research

The diversity and vitality of agricultural engineering programs at Cornell are demonstrated by the range of recent and current research and design projects. Work on the conservation, production, and use of energy includes projects on solar refrigeration, the control of heat loss in greenhouses, energy management on dairy farms, and biogas production from agricultural wastes. The mechanization of fruit and vegetable harvesting, integrated pest management, handling, processing, and storage continues to be a major area of study; projects include investigations of the influence of handling procedures and storage environments on product quality. Research in the area of agricultural-waste management includes the investigation of ways to minimize the environmental impact of agricultural production, and consideration of requirements for soil and water management. Environmentally sound approaches to the management of animal waste and food-processing waste are under study. Conservation and use of water resources is an area of active research, related to both domestic and international problems.

A feature of much of the research and project activity is systems analysis. This approach has been used to examine the influence of many interacting factors on the agricultural production system and the related environment. Typical specific subjects of analysis are product storage, physiological limits to animal productivity, biomass conversion, theory of failure for plant tissue, mathematical modeling of biological systems, and crop production in controlled-environment agriculture.

The many lines of research and project development are grouped into nine general areas:

Energy
Local Roads
Environmental Energy and Waste Management
Soil and Water Engineering
Food and Biological Engineering
International Agricultural Development
Power and Machinery
Handling and Processing Materials
Structures and Their Environment



Faculty Members and Their Professional Interests

Louis D. Albright, B.S.A.E., M.S., Ph.D. (Cornell): *greenhouses and agricultural buildings, energy management, computer simulation of thermal environment, solar applications*

Daniel J. Aneshansley, B.S.E.E (Cincinnati), M.S., Ph.D. (Cornell): *applications of electronics in biological systems, behavior of insects, applications of computers*

James A. Bartsch, B.S., M.S. (Wisconsin), Ph.D. (Purdue): *storage systems for horticultural crops, product damage, properties of food and biological materials*

Wilfried H. Brutsaert, B.S. (Ghent, Belgium), M.S., Ph.D. (California, Davis): *hydraulics, hydrology, groundwater flow*

J. Robert Cooke, B.S., M.S., Ph.D. (North Carolina State): *biological engineering, plant-water relationships, engineering properties of biological materials, mathematical engineering analysis, microcomputers*

Ronald B. Furry, B.S., M.S. (Cornell), Ph.D. (Iowa State): *controlled-atmosphere storage of fruits and vegetables, similitude methodology, plant and animal environments*

Kifle G. Gebremedhin, B.S.C.E., M.S., Ph.D. (Wisconsin): *structural analysis and design, animal housing systems, thermal environment, heat and mass transfer, modeling of animal energetics*

Richard W. Guest, P.E.; B.S., M.S. (North Dakota State): *agricultural waste and energy management, dairy and livestock engineering*

Wesley W. Gunkel, B.S. (North Dakota State), M.S. (Iowa State), Ph.D. (Michigan State): *energy, agricultural power and machinery, machine safety, pest control, materials handling, international agricultural mechanization*

Douglas A. Haith, B.S., M.S. (M.I.T.), Ph.D. (Cornell): *environmental-systems analysis, water-quality management, water resources*

Lynne H. Irwin, B.S., M.S. (California, Berkeley), Ph.D. (Texas A & M): *highway engineering, highway materials evaluation, soil stabilization, transportation in developing countries, community and resource development*

William J. Jewell, B.S. (Maine), M.E. (Manhattan College), Ph.D. (Stanford): *energy and waste treatment, unit process development, land-treatment costs, rural environmental engineering, agricultural-waste management*

David C. Ludington, B.S., M.S. (Cornell), Ph.D. (Purdue): *refrigeration and heat-pump systems, recovery and use of reject energy*

John L. Lumley, B.A. (Harvard), M.S.E., Ph.D. (Johns Hopkins): *fluid dynamics, turbulence and turbulence modeling, geophysical turbulence, stochastic processes*

William F. Millier, B.S., Ph.D. (Cornell): *agricultural power and machinery, mechanical harvesting and handling of tree fruits*

Jean-Yves Parlange, B.S. (Ecole Nationale Superiore de l'Aeronautique, Paris), Ph.D. (Brown): *mathematical modeling of physical and biological systems, applications of thermodynamics, water movement in soils*

Ronald E. Pitt, B.S., M.S. (Wisconsin), Ph.D. (Cornell): *forage systems, biological materials, mathematical modeling of biological systems*

Richard H. Rand, B.E. (Cooper Union), M.S., Sc.D. (Columbia): *biomechanics, theoretical and applied mechanics, dynamic systems*

Gerald E. Rehkugler, P.E.; B.S., M.S. (Cornell), Ph.D. (Iowa State): *design of agricultural and food-processing machinery, food engineering, solar refrigeration, vehicle dynamics*

Norman R. Scott, B.S.A.E. (Washington State), Ph.D. (Cornell): *biomathematical modeling of animal systems, animal calorimetry, environmental physiology, bioengineering, electronic instrumentation*

Christine A. Shoemaker, B.S. (California, Davis), M.S., Ph.D. (Southern California): *pest management, water-resource systems, mathematical ecology*

Tammo S. Steenhuis, B.S., M.S. (Wageningen, the Netherlands), Ph.D. (Wisconsin): *drainage; water management; interaction of water, soil, and chemicals; watershed hydrology*

Michael B. Timmons, B.S. (Ohio State), M.S. (Hawaii), Ph.D. (Cornell): *alternative energy systems, environmental control, ventilation, animal energetics*

Larry P. Walker, B.S., M.S., Ph.D. (Michigan State): *energy-systems engineering, mathematical modeling and optimization*

Michael F. Walter, B.S., M.S. (Illinois), Ph.D. (Wisconsin): *water resources, tropical water management, small-watershed hydrology, drainage*

Further Information

More detailed information is available in the publications *Department of Agricultural Engineering: The Staff and Program* and *Agricultural Engineering Research*. Requests for these publications and inquiries regarding any aspect of the graduate programs should be sent to the Graduate Faculty Representative, Agricultural Engineering, Cornell University, Riley-Robb Hall, Ithaca, New York 14853-5701.

Applied Mathematics

Because mathematics is intrinsic to all areas of engineering and applied science, the Field of Applied Mathematics at Cornell is interdisciplinary, with faculty members drawn from departments throughout the University. Research and study in this field are coordinated through the Center for Applied Mathematics. There are some sixty core faculty members associated with the center, and students sometimes do their research with other professors who are not formally members of the center. About thirty Ph.D. candidates are enrolled in the graduate field.

The graduate program is based on a solid foundation that includes the fundamentals of pure mathematics and the methods of applied mathematics. The remainder of an individual's program is designed by the student and his or her special committee. Courses are selected from those offered by a dozen academic departments. Students with undergraduate backgrounds that include a substantial mathematical component are eligible to apply.

Interested students should be aware that Cornell offers several different graduate programs in which applied mathematics can be studied. Those with well-defined interests should investigate the suitability of programs in the Fields of Computer Science, Mathematics, Operations Research, Statistics, and Theoretical and Applied Mechanics, as well as various other fields in the physical sciences and engineering. The Field of Applied Mathematics is particularly appropriate for those interested in classical or modern applied mathematics and for those undertaking truly interdisciplinary studies involving mathematics but lying between the areas encompassed by other graduate fields at Cornell.

Affiliated with the Center for Applied Mathematics is the Mathematical Sciences Institute (MSI), funded by the Department of Defense. MSI provides support for graduate students, postdoctoral fellows, and visiting faculty members.

Facilities

The Center for Applied Mathematics maintains faculty and student offices and seminar rooms in Sage Hall.

The center operates a DEC VAX 11/750 minicomputer with color-graphics terminals, including an AED 767. This machine is linked to the theorynet system of minicomputers in various other campus locations, including facilities of the Departments of Physics, Mathematics, and Computer Science, and via that network to the national ARPAnet. Theorynet also provides links to Cornell's IBM/FPS supercomputer.

Additional excellent computer services, as well as all other facilities of the University, are available to graduate students in the Field of Applied Mathematics.

Areas of Research

The extensive research possibilities include work in the following general subjects and applications: ordinary and partial differential equations, numerical analysis, functional analysis, mathematical physics, classical mechanics, dynamical systems, aerodynamics and fluid mechanics, astrophysics, statistical mechanics, applied probability, statistics, mathematical biology, population growth, genetics, logic, automata, networks, combinatorics, game theory, and mathematical economics.

Faculty Members and Their Research Interests

Toby Berger, B.E. (Yale), M.S., Ph.D. (Harvard): *information theory, statistical communication, random processes*

Louis J. Billera, B.S. (Rensselaer), M.S., Ph.D. (City University of New York): *combinatorics, game theory*

Robert G. Bland, B.S., M.S., Ph.D. (Cornell): *linear programming, combinatorial optimization, networks and matrices*

James A. Bramble, A.B. (Brown), M.S., Ph.D. (Maryland): *numerical analysis, partial differential equations*

Herbert J. Carlin, B.S., M.S. (Columbia), D.E.E., Ph.D. (Polytechnic Institute of Brooklyn): *microwave and network techniques*

Claude Cohen, B.S. (American University, Cairo), Ph.D. (Princeton): *fluid dynamics, transport phenomena, light scattering, polymer systems*

Thomas F. Coleman, B.Math., M.Math., Ph.D. (Waterloo): *numerical optimization, algorithms*

Robert Connelly, B.S. (Carnegie-Mellon), Ph.D. (Michigan): *geometry, topology*

Robert Constable, B.A. (Princeton), M.S., Ph.D. (Wisconsin): *theory of computing, automata, logic*

David F. Delchamps, B.S.E. (Princeton), S.M., Ph.D. (Harvard): *linear and nonlinear dynamical systems, control theory, estimation and identification*

Richard Durrett, B.S., Ph.D. (Stanford): *probability theory*

Eugene B. Dynkin, Cand.Sc., D.Sc. (Moscow): *probability theory*

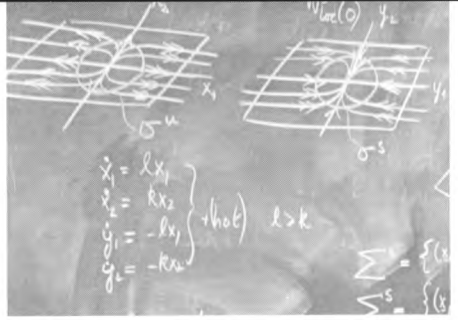
Gregory S. Ezra, B.A., D.Phil. (Oxford): *theoretical chemistry, chemical physics*

Roger H. Farrell, Ph.B., M.S. (Chicago), Ph.D. (Illinois): *mathematical statistics*

Terrence L. Fine, B.E.E. (City College of New York), S.M., Ph.D. (Harvard): *decision theory, foundations of probability, modeling*

Michael E. Fisher, B.Sc., Ph.D. (London): *foundations and applications of statistical mechanics, combinatorics*

Wolfgang H. J. Fuchs, B.A., Ph.D. (Cambridge): *mathematical methods of physics*



Leonard Gross, B.S., M.S., Ph.D. (Chicago): *analysis, mathematics of quantum theory*

Keith E. Gubbins, B.S., Ph.D. (London): *statistical mechanics of liquids, computer simulation of liquids*

John Guckenheimer, B.A. (Harvard), Ph.D. (California at Berkeley): *dynamical systems, differential equations*

David C. Heath, A.B. (Kalamazoo), M.S., Ph.D. (Illinois): *applied probability, stochastic control, game theory*

Chris Heegard, B.S., M.S. (Massachusetts, Amherst), Ph.D. (Stanford): *communications and information systems*

Philip Holmes, B.A. (Oxford), Ph.D. (Southampton): *nonlinear mechanics, dynamical systems, bifurcation theory*

John H. Hubbard, B.A. (Harvard), Dct. d'Etat (Paris-Sud): *ordinary differential equations, iteration, fractals*

Chung-Yuen Hui, B.A. (Wisconsin), M.S., Ph.D. (Harvard): *fracture mechanics, high-temperature crack propagation, geomechanics, asymptotic methods*

Robert A. Jarrow, B.A., M.B.A., Ph.D. (M.I.T.): *mathematical economics*

James T. Jenkins, B.S. (Northwestern), Ph.D. (Johns Hopkins): *nonlinear field theories in mechanics, continuum mechanics*

Harry Kesten, Doctorandus (Amsterdam), Ph.D. (Cornell): *probability theory*

Myunghwan Kim, B.S. (Alabama), M.E., Ph.D. (Yale): *biomathematics, bioengineering*

James A. Krumhansl, B.S. (Dayton), M.S. (Case), Ph.D. (Cornell): *solid-state physics, microscopic descriptions of macroscopic properties of materials*

Sidney Leibovich, B.S. (California Institute of Technology), Ph.D. (Cornell): *fluid dynamics, magnetohydrodynamics*

Simon A. Levin, B.A. (Johns Hopkins), Ph.D. (Maryland): *mathematical biology, differential equations*

Richard L. Liboff, A.B. (Brooklyn), Ph.D. (New York University): *kinetic theory, plasma physics, electrodynamics, quantum mechanics*

Geoffrey S. S. Ludford, B.A., M.A., Sc.D., Ph.D. (Cambridge): *fluid mechanics, magnetohydrodynamics, combustion and related applied mathematics*

Franklin Luk, B.S. (California Institute of Technology), M.S., Ph.D. (Stanford): *parallel matrix computations*

John L. Lumley, B.A. (Harvard), M.S.E., Ph.D. (Johns Hopkins): *fluid mechanics, turbulence, stochastic processes*

Mukul K. Majumdar, B.A. (Calcutta), M.A., Ph.D. (California, Berkeley): *mathematical economics*

Anil Nerode, A.B., B.S., M.S., Ph.D. (Chicago): *logic, recursive functions and computability, automata*

Lawrence E. Payne, B.S., M.S., Ph.D. (Iowa State): *partial differential equations*

S. Leigh Phoenix, B.Sc., M.Sc. (Guelph), Ph.D. (Cornell): *mechanical reliability, probabilistic theories of material failure, composite materials, fracture mechanics*

Narahari U. Prabhu, B.A. (Madras), M.A. (Bombay), M.Sc. (Manchester): *stochastic processes, analysis and control of stochastic systems*

Richard H. Rand, B.E. (Cooper Union), M.S., Engr.Sc.D. (Columbia): *differential equations, dynamical systems, biomechanics*

Edwin E. Salpeter, B.Sc., M.S. (Sydney), Ph.D. (Birmingham): *theoretical astrophysics, nuclear theory, statistical mechanics*

Thomas J. Santner, B.S. (Dayton), M.S., Ph.D. (Purdue): *biomedical statistics, discrete data, selection theory*

Alfred H. Schatz, B.S. (City College of New York), M.S., Ph.D. (New York University): *numerical analysis, partial differential equations*

Shan-Fu Shen, B.S. (National Central University, China), Sc.D. (M.I.T.): *aerodynamics, rarefied gas dynamics*

Christine Shoemaker, B.S. (California, Davis), M.S., Ph.D. (Southern California): *applications of optimization methods to environmental and ecological problems*

Frank L. Spitzer, B.A., M.A., Ph.D. (Michigan): *probability theory and analysis*

Paul H. Steen, Sc.B., A.B. (Brown), Ph.D. (Johns Hopkins): *hydrodynamic stability, nonlinear fluid dynamics*

Howard M. Taylor 3d, B.M.E., M.I.E. (Cornell), Ph.D. (Stanford): *applied probability and statistics*

James S. Thorp, B.E.E., M.S., Ph.D. (Cornell): *optimal control with application to power systems and robotics*

Michael J. Todd, B.A. (Cambridge), Ph.D. (Yale): *mathematical programming, combinatorics*

Leslie E. Trotter, A.B. (Princeton), M.S. (Georgia Institute of Technology), Ph.D. (Cornell): *discrete optimization*

Charles Van Loan, B.S., M.A., Ph.D. (Michigan): *numerical analysis*

Lars B. Wahlbin, B.A., M.A., Ph.D. (Göteborg, Sweden): *numerical analysis of partial differential equations*

Lionel I. Weiss, B.A., M.A., Ph.D. (Columbia): *statistical decision theory*

Benjamin Widom, A.B. (Columbia), Ph.D. (Cornell): *physical chemistry, statistical mechanics*

Further Information

Additional information may be obtained by writing to Michael J. Todd, Graduate Faculty Representative, Center for Applied Mathematics, Cornell University, Sage Hall, Ithaca, New York 14853-6201.

Applied Physics

The Graduate Field of Applied Physics offers opportunities for advanced study and research in many areas of science and applied science that are based on the principles and techniques of physics. The program is designed to provide students who have an undergraduate training in physics, applied physics, or a related engineering field with a graduate education that combines a core physics curriculum with research and study in one of numerous areas that deal either with the application of physics or with the interface between physics and one of the other sciences.

The faculty is centered in the School of Applied and Engineering Physics of the College of Engineering, but also includes members from many other academic units of the University. These include Astronomy, Biochemistry, Chemical Engineering, Electrical Engineering, Geological Sciences, Materials Science and Engineering, Mechanical and Aerospace Engineering, Neurobiology and Behavior, Nuclear Physics, Physics, and Theoretical and Applied Mechanics. Together, the more than fifty members of the field faculty provide the student with a very broad range of research opportunities.

About one hundred students are enrolled in the graduate field, studying for M.S. or Ph.D. degrees. These students conduct thesis research and take courses in physics and related subjects; an interdisciplinary approach is encouraged, and students generally minor in an area such as electrical engineering, chemistry, or materials science. Also available is the M.Eng.(Engineering Physics) degree program, a versatile course of study that can lead to professional employment or to further graduate work in physics, applied physics, or interdisciplinary fields.

Facilities

Because of the interdepartmental and interdisciplinary nature of the graduate Field of Applied Physics at Cornell, the facilities available for graduate research are much more extensive than those generally provided by a single department. Moreover, the individual research laboratories are notable for their high level of advanced instrumentation, in keeping with the emphasis the faculty places on staying at the leading edge of research technology. Equally notable is the quality and breadth of such research support facilities as machine shops and stockrooms.

Cornell's initiative in promoting interdisciplinary research is an important factor in its position as a leading research university. A number of scientific and engineering research organizations have been established at the University. All of them receive very substantial outside funding, and several are unique national facilities. They include the Biotechnology Program, the Center for Radiophysics and Space Research, the Cornell High Energy Synchrotron Source (CHESS), the Laboratory of Plasma Studies, the Materials Science Center, the National Astronomy and Ionosphere Center, the National Research and Resource Facility for Submicron Structures (NRRFSS), the Semiconductor Research Corporation Center for Microscience and Technology, and the Ward Laboratory of Nuclear Engineering.

Since applied physics research is interdisciplinary research, members of the field faculty have played substantial roles in the formation, operation, and research programs of all these centers and facilities. Nearly all graduate students in applied physics benefit from these resources.

Areas of Research

The broad applicability of the principles and techniques of physics is demonstrated by the many diverse research areas within the Field of Applied Physics. Recent research has been conducted in ten general areas:

Solid-State Physics and Materials Science

Plasma Physics

Biophysics

Quantum Optics, Laser Physics, and Nonlinear Optics

Atomic, Molecular, and Chemical Physics

Statistical Physics

Geophysics

Astrophysics

Low-Energy Nuclear Physics

Electron and Ion Optics

Faculty Members and Their Research Interests

Dieter Ast, Dipl.Phys. (Stuttgart), Ph.D. (Cornell): *amorphous materials and polymeric materials*

Peter L. Auer, A.B. (Cornell), Ph.D. (California Institute of Technology): *plasma physics, energy policy*

Joseph M. Ballantyne, B.S., B.S.E.E. (Utah), S.M., Ph.D. (M.I.T.): *semiconductor lasers and detectors, integrated optical devices, solar cells*

Boris W. Batterman, B.S. Ph.D. (M.I.T.): *x-ray and neutron diffraction, synchrotron radiation, solid-state physics*

John M. Blakely, B.S., Ph.D. (Glasgow): *surface physics and chemistry*

Robert A. Buhrman, B.S. (Johns Hopkins), Ph.D. (Cornell): *superconducting devices, solid-state and low-temperature physics, submicron lithography*

K. Bingham Cady, S.B., Ph.D. (M.I.T.): *nuclear engineering, modeling of accident transients, nuclear reactor physics*

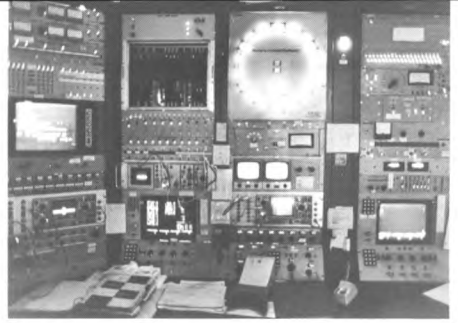
David D. Clark, A.B., Ph.D. (California, Berkeley): *experimental nuclear and reactor physics*

Terrill A. Cool, B.S. (California, Los Angeles), M.S., Ph.D. (California Institute of Technology): *molecular lasers, chemical physics*

P. C. Tobias de Boer, Ir.(M.E.) (Delft, the Netherlands), Ph.D. (Maryland): *high-temperature gasdynamics, plasma physics*

Lester F. Eastman, B.E.E., M.S., Ph.D. (Cornell): *compound semiconductor epitaxy, physical electronics of microwave and optical solid-state devices*

Donald T. Farley, B.E.P., Ph.D. (Cornell): *ionospheric physics, radio propagation*



Michael E. Fisher, B.Sc., Ph.D. (London): *mathematical physics, statistical mechanics, phase transitions and critical phenomena*

Hans H. Fleischmann, Dipl.Phys., Dr.rer.nat. (Technical University, Munich): *plasma physics, thermonuclear fusion*

Edward R. Grant, B.A. (Occidental), Ph.D. (California, Davis): *molecular and chemical physics*

Keith E. Gubbins, B.S, Ph.D. (London): *statistical mechanics of liquids, liquid surfaces*

David A. Hammer, B.S. (California Institute of Technology), Ph.D. (Cornell): *plasma physics, nuclear fusion, high-power electron- and ion-beam physics*

Martin O. Harwit, B.A. (Oberlin), Ph.D. (M.I.T.): *astrophysics*

James R. Houck, B.S. (Carnegie-Mellon), Ph.D. (Cornell): *astrophysics*

Paul L. Houston, B.S. (Yale), Ph.D. (M.I.T.): *molecular and chemical physics*

Michael S. Isaacson, B.S. (Illinois, Urbana), S.M., Ph.D. (Chicago): *scanning transmission electron microscopy*

Bryan L. Isacks, A.B., Ph.D. (Columbia): *seismology, global tectonics*

Herbert H. Johnson, B.S., M.S., Ph.D. (Case): *mechanical behavior of solids*

Michael C. Kelley, B.S. (Kent State), Ph.D. (California, Berkeley): *space plasma physics, rocket and satellite instrumentation*

Paul M. Kintner, B.S. (Rochester), Ph.D. (Minnesota): *space plasma physics, digital signal processing*

Vaclav O. Kostroun, B.Sc., M.Sc. (Washington), Ph.D. (Oregon): *low-energy nuclear and atomic physics*

Edward J. Kramer, B.Ch.E. (Cornell), Ph.D. (Carnegie-Mellon): *low-temperature physics, polymers*

James A. Krumhansl, B.S. (Dayton), M.S. (Case), Ph.D. (Cornell): *theoretical and applied physics*

J. Peter Krusius, Dipl.Eng., Lic.Tech., D.Tech. (Helsinki University of Technology): *VLSI and submicron technology, CAD for VLSI*

Arthur F. Kuckes, B.S. (M.I.T.), Ph.D. (Harvard): *geophysics, drilling technology*

Bruce R. Kusse, B.S., Ph.D. (M.I.T.): *electron-beam physics, plasma physics*

Charles A. Lee, B.E.E. (Rensselaer), Ph.D. (Columbia), *solid-state physics*

Aaron Lewis, B.S. (Missouri), Ph.D. (Case Western Reserve): *cellular biophysics, transduction mechanisms in visual photoreceptor cells, active transport across cell membranes*

Richard L. Liboff, A.B. (Brooklyn), Ph.D. (New York University): *kinetic theory, plasma physics, electrodynamics, quantum mechanics*

Richard V. E. Lovelace, B.S. (Washington), Ph.D. (Cornell): *plasma physics theory, astrophysics*

Noel C. MacDonald, B.S.E.E., M.S., Ph.D. (California, Berkeley): *electron-beam technology*

James W. Mayer, B.S., Ph.D. (Purdue): *ion implantation in semiconductors, thin-film reactions, Rutherford backscattering and channeling*

Robert Merrill, Chem.E. (Cornell), Sc.D. (M.I.T.): *surface physics*

Keith Moffat, B.S. (Edinburgh), Ph.D. (Cambridge): *protein crystallography, structure and function of proteins*

John A. Nation, B.Sc., Ph.D. (Imperial College, London): *plasma physics, thermonuclear fusion*

Mark S. Nelkin, B.S. (M.I.T.), Ph.D. (Cornell): *statistical physics, turbulent fluid flow*

Jack E. Oliver, B.A., M.A., Ph.D. (Columbia): *seismology, global tectonics*

Clifford R. Pollock, B.S., M.S., Ph.D. (Rice): *lasers, molecular spectroscopy, quantum electronics*

Thor N. Rhodin, B.S. (Haverford), A.M., Ph.D. (Princeton): *physics and chemistry of surfaces and interfaces of metals and semiconductors*

Arthur L. Ruoff, B.S. (Purdue), Ph.D. (Utah): *ultra-pressure phenomena, reactive ion-beam etching, inorganic resists*

Miriam M. Salpeter, B.A. (Hunter), M.S., Ph.D. (Cornell): *biophysics*

Charles E. Seyler, Jr., B.A., M.A. (South Florida), Ph.D. (Iowa): *plasma physics, thermonuclear fusion, high-power beams, space plasmas*

Benjamin M. Siegel, B.S., Ph.D. (M.I.T.): *ion-beam lithography for nanometer structuring and device fabrication, charged-particle optics, field-ionization sources, computer image processing*

John Silcox, B.Sc. (Bristol), Ph.D. (Cambridge): *electron microscopy, spectroscopy, diffraction*

Roger M. Spanswick, B.Sc. (Birmingham), Dipl.Biophys., Ph.D. (Edinburgh): *biophysics, ion transport*

Ravindra N. Sudan, B.A. (Punjab, India), D.I.I.Sc. (Indian Institute of Science), D.I.C. (Imperial College, London), Ph.D. (London): *plasma physics*

Chung L. Tang, B.S. (Washington), M.S. (California Institute of Technology), Ph.D. (Harvard): *quantum electronics*

Donald L. Turcotte, B.S. (California Institute of Technology), M.Aero.E. (Cornell), Ph.D. (California Institute of Technology): *aerospace engineering, gasdynamics, geophysics*

Watt W. Webb, B.S., Sc.D. (M.I.T.): *biological physics, fluctuations and cooperative phenomena in solids and liquids, physical optics*

Charles B. Wharton, B.S., M.S. (California, Berkeley): *plasma physics, microwave electronics*

John R. Wiesenfeld, B.S. (City College of New York), Ph.D. (Case), M.S. (Cambridge): *physical chemistry and chemical physics*

Edward D. Wolf, B.S. (McPherson), Ph.D. (Iowa State): *microminiaturization science and technology*

George J. Wolga, B.E.P. (Cornell), Ph.D. (M.I.T.): *magneto-optics, quantum electronics, light scattering in solids, photoacoustic spectroscopy*

Further Information

Additional information may be obtained by writing to Robert A. Buhrman, Graduate Faculty Representative, Applied Physics, Cornell University, Clark Hall, Ithaca, New York 14853-2501.

Chemical Engineering

The graduate programs in chemical engineering at Cornell strike a balance between the scientific and the more empirical approaches. This blend provides students with a strong base in the fundamentals of chemical engineering and with the ability to apply these fundamentals to significant engineering problems.

About seventy students and twenty faculty members are involved in the programs of the graduate Field of Chemical Engineering; the moderate size of the department promotes close interactions among graduate students, faculty members, visiting scientists, and postdoctoral fellows, and a friendly atmosphere for work and study. The range of study and research is unusually broad, however. Chemical engineering graduate students may take course work not only in their own field but in areas such as other engineering disciplines, the physical sciences, the biological sciences, business administration, economics, and law. Research may be undertaken in any of the chemical engineering specialty areas or in interdisciplinary subjects.

The close association of chemical engineering with many other disciplines at Cornell is a source of vitality in the graduate program. Cooperative efforts are encouraged by the system of graduate fields and by the presence of a number of interdisciplinary laboratories and centers. Many of the chemical engineering professors are also members of other graduate fields, such as Applied Mathematics, Applied Physics, Chemistry, Food Science, Materials Science and Engineering, and Microbiology; many participate in the programs of special laboratories such as the Biotechnology Center, the Center for Theory and Simulation in Science and Engineering (the Theory Center), the Materials Science Center, and the National Research and Resource Facility for Submicron Structures. Graduate students have the opportunity to draw upon and contribute to the various interdisciplinary efforts.

The faculty is an outstanding group of professionals with a strong commitment to research and teaching, and in addition, many of them serve as consultants to industry and government. Four members of the school faculty are authors or coauthors of textbooks that are in common use throughout the country.

Three graduate degrees are offered: the professional M.Eng.(Chemical), the M.S., and the Ph.D. Master's degree work may be applied toward the doctorate.

Most M.S. and Ph.D. students take core courses in chemical engineering thermodynamics, applied chemical kinetics, transport phenomena, and mathematical methods of chemical engineering analysis. In addition, a variety of specialized advanced courses is offered. Design-oriented courses intended primarily for M.Eng. students may also be taken by M.S. and Ph.D. candidates.

Facilities

Recently refurbished general laboratories for graduate research are supplemented by specialized laboratories for work in biochemical engineering, computer simulation, kinetics and catalysis, polymer science, surface science, thermodynamics, and transport phenomena. Also, graduate researchers have access to the various interdisciplinary facilities at the University.

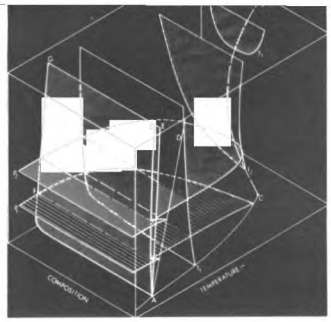
The University's excellent computer system is used in many research projects, and in addition, the School of Chemical Engineering has extensive modern computing facilities of its own.

Areas of Research

Research in chemical engineering addresses an enormous range of technical problems involved in urgent needs such as more efficient use of energy resources, the development of alternative energy sources, protection of air and water quality, effective disposal of effluent wastes, expansion of food supplies, and advances in biomedical engineering. Although specific projects at Cornell may address such problems directly, the emphasis is on fundamental principles that can be broadly applied.

Active programs are in progress in the following general areas:

Biochemical Engineering
Applied Mathematics
Computer Simulation
Environmental Engineering
Kinetics and Catalysis
Surface Science
Heat and Mass Transfer
Polymer Science and Engineering
Fluid Dynamics
Rheology and Biorheology
Reactor Design
Molecular Thermodynamics
Statistical Mechanics



Faculty Members and Their Research Interests

A. Brad Anton, B.S. (Virginia Polytechnic Institute), M.S., Ph.D. (California Institute of Technology): *mechanisms of reaction on crystal surfaces*

Paulette Clancy, B.Sc. (London), D.Phil. (Oxford): *applications of computers in chemical engineering, molecular thermodynamics of fluid mixtures*

Claude Cohen, B.S. (American University, Cairo), Ph.D. (Princeton): *thermodynamic and transport properties of polymer solutions, physical properties of bulk polymers, light scattering*

Robert K. Finn, Chem.E. (Cornell), Ph.D. (Minnesota): *waste treatment, agitation and aeration, microbial kinetics*

Keith E. Gubbins, B.S., Ph.D. (London): *molecular thermodynamics of liquid mixtures, phase equilibria, computer simulation studies of liquids*

Daniel A. Hammer, B.S.E. (Princeton), M.S.E., Ph.D. (Pennsylvania): *cell-surface adhesion, cell separations, applied mathematics*

Peter Harriott, Chem.E. (Cornell), Sc.D. (M.I.T.): *kinetics, catalysis, and reactor design; synthetic fuels; air pollution control; diffusion in membranes and porous solids*

Donald L. Koch, B.A., B.S. (Case), Ph.D. (M.I.T.): *transport processes, fluid mechanics, prediction of macroscopic properties of disordered media, applied mathematics, turbulence*

Robert P. Merrill, Chem.E. (Cornell), Sc.D. (M.I.T.): *chemistry and physics of reactive solid surfaces, catalysis, corrosion, electron spectroscopy of surfaces, atomic and molecular beam scattering*

William L. Olbricht, B.S. (Stanford), Ph.D. (California Institute of Technology): *non-Newtonian fluid mechanics, rheology, flow in porous media, biomedical fluid mechanics*

Athanassios Z. Panagiotopoulos, B.S. (National Technical University of Athens), Ph.D. (M.I.T.): *thermodynamics of fluid mixtures, colloidal solutions, computer simulation techniques*

Ferdinand Rodriguez, B.S., M.S. (Case), Ph.D. (Cornell): *polymerization, properties of polymer systems*

George F. Scheele, B.S. (Princeton), Ph.D. (Illinois): *hydrodynamic stability, coalescence, fluid mechanics of liquid drops and jets, computer-aided design*

Michael L. Shuler, B.S. (Notre Dame), Ph.D. (Minnesota): *biochemical engineering, unconventional foods, plant cells, novel biological reactors, mathematical models of cell growth, waste treatment, immobilized cells*

Paul H. Steen, Sc.B., A.B. (Brown), Ph.D. (Johns Hopkins): *hydrodynamic stability, nonlinear mechanisms of convection in porous media, flows induced by surface-tension gradients*

William B. Streett, B.S. (West Point), Ph.D. (Michigan): *measurement of thermodynamic properties of fluids at high pressures, computer simulation of molecular liquids*

Raymond G. Thorpe, B.Ch.E. (Rensselaer), M.Ch.E. (Cornell): *phase equilibria, fluid flow*

Robert L. Von Berg, B.S., M.S. (West Virginia), Sc.D. (M.I.T.): *liquid-liquid extraction, effects of radiation of chemical reaction, saline-water conversion*

Herbert F. Wiegandt, B.S., Ph.D. (Purdue): *hydraulics of porous moving beds, petroleum processing, saline-water conversion*

John A. Zollweg, A.B. (Oberlin), Ph.D. (Cornell): *experimental thermodynamics, interfacial phenomena, computer simulation*

Further Information

Prospective candidates for graduate degrees in chemical engineering may obtain further information by writing to Professor Claude Cohen, Graduate Faculty Representative, Cornell University, Chemical Engineering, Olin Hall, Ithaca, New York 14853-5201.

Civil and Environmental Engineering

Civil and environmental engineering encompasses a wide range of activities. At Cornell these activities are carried out by two departments in the School of Civil and Environmental Engineering: Structural Engineering, concerned primarily with the planning, design, construction, and operation of bridges, buildings, dams, public facilities, and other large fixed works; and Environmental Engineering, concerned with environmental systems, environmental quality, environmental law, transportation, hydraulics, hydrology, water resources, and remote sensing.

Well over one hundred students are enrolled in graduate programs that lead to the degrees of M.Eng.(Civil), M.S., or Ph.D. Major subject areas for M.S. and Ph.D. candidates are remote sensing, environmental engineering, environmental systems engineering, geotechnical engineering, hydraulics and hydrology, structural engineering, transportation engineering, and water resource systems. Minor subjects may be in these areas, in other branches of engineering, or in nonengineering subjects relevant to the major.

In the professional M.Eng.(Civil) degree program, the emphasis is on design and design-oriented courses in any one of the broad areas of the discipline. An outstanding feature is the involvement of practicing engineers as consultants in real-life project work, which is carried out partly during an intensive three-week work period between academic semesters.

Facilities

In the structural engineering area, three special laboratories are used to carry out a considerable volume of research sponsored by government agencies and industry. The George Winter Laboratory, with a three-story-high test bay for structural steel members and assemblies, is one of the largest and best equipped of its kind in any university. The Concrete Materials Laboratory provides facilities for all types of basic and applied research in concrete. The unusually well equipped Structural Models Laboratory is used for both research and instructional modeling.

The geotechnical engineering laboratory has a wide variety of standard and specialized equipment for testing soils, rock, and asphaltic mixtures under static and dynamic loading conditions. A second laboratory has been dedicated to the large-scale model testing of foundations under complex loadings and to the testing of buried pipeline systems. In addition, a field facility has been developed for testing buried pipeline systems under prototype loading conditions.

Laboratory facilities in hydraulics and hydrology have been greatly expanded and enhanced by the new 5,000-square-foot Joseph H. DeFrees Hydraulics Laboratory, which will be used for a variety of research and teaching functions in hydraulics and environmental fluid mechanics. The facilities will include three major pieces of equipment: a wave flume (stretching more than two-thirds the length of the laboratory) with a random-wave generator for studying ocean waves and related coastal engineering problems; a slightly shorter wind-water tunnel for study of atmospheric-hydraulic interactions; and a tilting flume of the same length for studying problems related to rivers and estuaries.

The environmental engineering facilities include laboratories for work in specialized areas such as biological oxidation kinetics and aquatic chemistry. Equipment is available for bench and pilot-level unit process studies in biological treatment, carbon adsorption, ion exchange, electrodialysis, and reverse osmosis. In addition, a wide array of sophisticated analytical equipment is available for detailed physical, chemical, and biological analysis of field and laboratory samples.

Research in environmental law is greatly facilitated by the accessibility of the nearby Law School library.

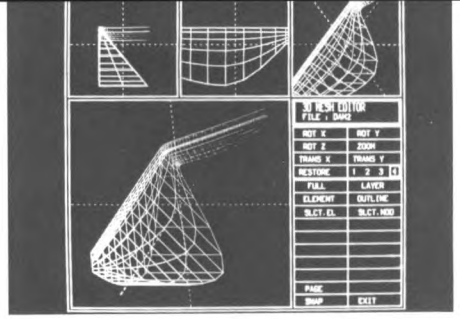
Remote-sensing facilities include an extensive library of satellite, aircraft, and other multispectral and thermal imageries. Equipment for visual and digital image analysis is readily available. Image processing is done by an international imaging System Model 70 connected to a VAX 11/750.

State-of-the-art interactive computer-graphics facilities, some of the finest in any university, are used for research in many areas of civil and environmental engineering. The VAX 11/750 operated by the School complements the University computing system and the many microcomputer and data-acquisition systems.

Areas of Research

Research activities in the Field of Civil and Environmental Engineering fall into several broad groups:

Remote Sensing
Geotechnical Engineering
Structural Engineering
Hydraulics and Hydrology
Environmental (Sanitary) Engineering
Environmental Systems Engineering
Transportation Engineering and Planning
Water Resource Systems



Faculty Members and Their Professional Interests

Environmental Engineering

James J. Bisogni, Jr., B.S. (Lehigh), M.S., Ph.D. (Cornell): *sanitary engineering, applied aquatic chemistry*

Wilfried H. Brutsaert, Eng. (State University, Ghent, Belgium), M.S., Ph.D. (California, Davis): *hydraulics, hydrology, groundwater flow*

Richard I. Dick, B.S. (Iowa State), M.S. (State University of Iowa), Ph.D. (Illinois): *water and wastewater treatment, sludge treatment and disposal*

Leonard B. Dworsky, B.S. (Michigan), M.S. (American): *water-resource planning, management, and policy*

Gordon P. Fisher, P.E.; B.E., Dr.Eng. (Johns Hopkins): *transportation-systems analysis, traffic flow theory, public systems, engineering economics, urban goods movement*

James M. Gossett, B.S., M.S., Ph.D. (Stanford): *sanitary engineering, biological treatment processes*

Douglas A. Haith, B.S., M.S. (M.I.T.), Ph.D. (Cornell): *water-resource systems, nonpoint-source pollution*

Gerhard H. Jirka, Dipl.Ing. (Vienna, Austria), M.S., Ph.D. (M.I.T.): *fluid mechanics, turbulent heat and mass transport processes, hydraulics*

James A. Liggett, B.S. (Texas Technological), M.S., Ph.D. (Stanford): *hydraulics, fluid mechanics and hydrology*

Leonard W. Lion, B.S. (Loyola, Los Angeles), M.S., Ph.D. (Stanford): *environmental engineering, biogeochemical fate of pollutants*

Philip L.-F. Liu, B.S. (National Taiwan), S.M., Sc.D. (M.I.T.): *fluid mechanics, coastal engineering*

Daniel P. Loucks, B.S. (Pennsylvania State), M.S. (Yale), Ph.D. (Cornell): *systems for water-resource and environmental management, interactive computer graphics*

Walter R. Lynn, P.E.; B.S.C.E. (University of Miami), M.S.C.E. (North Carolina), Ph.D. (Northwestern): *environmental-systems analysis, public health, models for water-quality management*

Arnim H. Meyburg, B.A. Equiv. (Free University of Berlin), M.S., Ph.D. (Northwestern): *urban and freight transportation; public-transit operations; transportation-systems analysis; transportation and communications*

Neil Orloff, B.S. (M.I.T.), M.B.A. (Harvard), J.D. (Columbia): *environmental law, regulation of toxic substances, technology assessment*

Warren R. Philipson, B.C.E., M.S., Ph.D. (Cornell): *remote sensing, aerial photography, physical environment*

William D. Philpot, B.A. (New York University), B.S. (SUNY, Stonybrook), M.S., Ph.D. (Delaware): *remote sensing, radiative transfer, image processing*

Richard E. Schuler, P.E.; B.E. (Yale), M.B.A. (Lehigh), M.A., Ph.D. (Brown): *urban, spacial, transportation, and energy economics; public finance; utility regulation*

Christine Shoemaker, B.S. (California, Davis), M.S., Ph.D. (Southern California): *pest management, water-resource systems, mathematical ecology*

Jery R. Stedinger, A.B. (California, Berkeley), A.M., Ph.D. (Harvard): *stochastic hydrology, water-resource systems, ecosystem management*

Mark A. Turnquist, B.S. (Michigan State), S.M., Ph.D. (M.I.T.): *transportation-systems analysis, transportation economics*

Structural Engineering

John F. Abel, P.E.; B.S. (Cornell), M.S. (Stanford), Ph.D. (California, Berkeley): *numerical methods, finite-element analysis, computer graphics, magnetothermomechanics*

Peter Gergely, P.E.; B.Eng. (McGill), M.S., Ph.D. (Illinois): *structural mechanics, shells, dynamics, earthquake engineering, reinforced concrete*

Donald P. Greenberg, B.C.E., Ph.D. (Cornell): *computer graphics, cable structures*

Mircea Grigoriu, Dipl.Math. (University of Bucharest), Ph.D. (M.I.T.): *structural reliability, structural analysis*

Kenneth C. Hover, B.S.C.E., M.S.C.E. (Cincinnati), Ph.D. (Cornell): *concrete materials, concrete structures*

Anthony R. Ingraffea, P.E.; B.S. (Notre Dame), M.S. (Polytechnic Institute of New York), Ph.D. (Colorado): *structural mechanics, fracture mechanics, numerical modeling and testing of rock and concrete fracture*

Fred H. Kulhawy, P.E.; B.S.C.E., M.S.C.E. (Newark College of Engineering), Ph.D. (California, Berkeley): *soil-structure interaction, rock engineering, finite-element modeling, marine and coastal geotechnique, geomechanics*

William McGuire, P.E.; B.S.C.E. (Bucknell), M.C.E. (Cornell): *performance and design of metal structures, computer graphics*

Arthur H. Nilson, P.E.; B.S. (Stanford), M.S.(Cornell), Ph.D. (California, Berkeley): *reinforced and prestressed concrete, light-gauge steel structures*

Thomas D. O'Rourke, B.S. (Cornell), M.S., Ph.D. (Illinois): *soil-structure interaction, analytical methods, underground structures, geotechnical instrumentation*

Teoman Peköz, B.S. (Robert College), M.S. (Harvard), Ph.D. (Cornell): *stability; cold-formed, thin-walled steel structures*

Floyd O. Slate, B.S., M.S., Ph.D. (Purdue): *physical and chemical properties of engineering materials*

Harry E. Stewart, P.E.; B.S. (SUNY, Brockport), B.S.C.E. (SUNY, Buffalo), Ph.D. (Massachusetts): *soil behavior, soil dynamics, instrumentation, railroad track*

Richard N. White, P.E.; B.S., M.S., Ph.D. (Wisconsin): *model analysis, nuclear reactor structures, concrete structures*

Further Information

Further information may be obtained by writing to the Graduate Faculty Representative, Civil and Environmental Engineering, Cornell University, Hollister Hall, Ithaca, New York 14853-3501.

Computer Science

Research in computer science at Cornell is concerned with the fundamental concepts and characteristic phenomena that arise in the creation and use of computing systems. This includes study of the limitations of computers, the principles underlying the mechanical processing of information, the design of efficient and reliable algorithms, and the organization of information for computer processing. It also involves the development of methods for writing good programs and engineering large-scale systems.

Various aspects of computer science are closely related to many other fields, including pure and applied mathematics, electrical engineering, linguistics, industrial engineering, business administration, psychology, and biology. In the past the various applications of machine computing have been studied in these different fields, but now their common basis is being increasingly recognized. At Cornell the graduate Field of Computer Science maintains a close association with other fields, particularly Electrical Engineering and Operations Research, but it has developed a strong program in computer or information science as an independent discipline. Cornell's leadership in the development of computer science is indicated by its recent ranking among the top five departments in the nation and by the wide use of a score of textbooks written at Cornell.

About ninety graduate students are enrolled in M.S. and Ph.D. degree programs in computer science. Applicants should have significant experience in programming, a solid background in mathematics, and the necessary prerequisites for graduate-level courses in the specialization chosen. Students who are interested primarily in computer components and logical design rather than in the use of computers may find it more appropriate to apply to the Field of Electrical Engineering.

Facilities

The department's research computing facility consists of two VAX 11/780s, two VAX 11/750s, ten Sun workstations, and a Gould 9080, all running on Berkeley UNIX, plus several Symbolics LISP machines, thirty Xerox Dandelion workstations, and various other personal computers, servers, and workstations, all connected via an Ethernet local network. Other Cornell computing facilities include an IBM 3081, two IBM 4341s, a DEC 2060, numerous VAXs and other superminicomputers, a graphics research laboratory, an instructional graphics facility, and large numbers of personal computers for instructional use. Cornell is also the site of an NSF-funded supercomputer center consisting of an IBM 3084 mainframe with attached array processors, plus UNIX front-end machines and experimental parallel computers.

Areas of Research

Algorithms
Computing Theory
Concurrency and Distributed Computing
Database Systems and Operating Systems
Information Organization and Retrieval
Numerical Analysis
Programming Environments
Programming Languages and Methodology
Robotics
VLSI

Faculty Members and Their Research Interests

Özalp Babaoğlu, B.S. (George Washington), M.S., Ph.D. (California, Berkeley): *distributed systems, performance evaluation*

Gianfranco Bilardi, Laurea (Padova, Italy), M.S., Ph.D. (Illinois): *computational complexity, VLSI*

Kenneth Birman, B.S. (Columbia), M.S., Ph.D. (California, Berkeley): *fault-tolerant distributed systems, knowledge-based signal processing*

Dina Bitton, B.S., M.Sc. (Technion, Israel), Ph.D. (Wisconsin): *databases*

James Bramble, A.B. (Brown), M.S., Ph.D. (Maryland): *numerical analysis*

Thomas F. Coleman, B.Math., M.Math., Ph.D. (Waterloo): *numerical analysis*

Robert L. Constable, B.A. (Princeton), M.A., Ph.D. (Wisconsin): *computational complexity, formal semantics and proof of theory of programming logics*

John R. Gilbert, B.S. (New Mexico), Ph.D. (Stanford): *analysis of algorithms, combinatorial algorithms for numerical problems*

Donald P. Greenberg, B.S.E., Ph.D. (Cornell): *computer graphics, computer-aided design, image processing*

David Gries, B.S. (Queens), M.S. (Illinois), Dr.rer.nat. (Technical University, Munich): *programming languages, programming methodology, compiler construction*

Juris Hartmanis, Cand.Phil. (Marburg), M.A. (Kansas City), Ph.D. (California Institute of Technology): *theory of computation*

John E. Hopcroft, B.S. (Seattle), M.S., Ph.D. (Stanford): *algorithms, robotics*
Dexter Kozen, B.A. (Dartmouth), M.S., Ph.D. (Cornell): *theory of computation, computational complexity, program logic and semantics*

Franklin Luk, B.S. (California Institute of Technology), M.S., Ph.D. (Stanford): *numerical analysis*

Keith Marzullo, A.B. (Occidental), M.S., Ph.D. (Stanford): *distributed systems*

Abha Moitra, M.S. (Birla), Ph.D. (Bombay): *programming methodology*

Anil Nerode, A.B., B.S., M.S., Ph.D. (Chicago): *logic, applied mathematics*

Alexandru Nicolau, B.A. (Brandeis), M.S., Ph.D. (Yale): *parallel computing, compiler system architectures and programming languages*

Prakash Panangaden, M.Sc. (Indian Institute of Technology, Kanpur), M.S. (Chicago), Ph.D. (Wisconsin, Milwaukee): *programming language semantics, logics, distributed systems, automated reasoning*

Keshav Pingali, B.Tech. (Indian Institute of Technology, Kanpur), S.M.E.E., Sc.D. (M.I.T.): *multiprocessor architectures, data flow, logic and functional programming languages, formal semantics*

Gerard Salton, A.B., M.A. (Brooklyn), Ph.D. (Harvard): information organization and retrieval

Fred B. Schneider, B.S., M.S. (Cornell), Ph.D. (SUNY, Stony Brook): *concurrent programming, operating systems, distributed systems*

Alberto Segre, B.S., A.B., M.S., Ph.D. (Illinois): *artificial intelligence, expert systems*

Jon Solworth, B.A., M.S., Ph.D. (New York University): *VLSI, computer-aided design, computer architectures*

Ray Teitelbaum, B.S. (M.I.T.), Ph.D. (Carnegie-Mellon): *programming languages and systems*

Sam Toueg, B.S. (Technion, Israel), M.S.E., M.A., Ph.D. (Princeton): *computer networks and protocols, distributed computing*

Charles Van Loan, B.S., M.A., Ph.D. (Michigan): *numerical analysis*

Vijay Vazirani, B.S. (M.I.T.), Ph.D. (California, Berkeley): *cryptography, alogorithms, computational complexity, VLSI*

Further Information

Additional information may be obtained by writing to Charles Van Loan, Graduate Faculty Representative, Computer Science, Cornell University, Upson Hall, Ithaca, New York 14853-7501.

Electrical Engineering

Electrical engineering is one of the most active fields of research at Cornell. Fundamental and innovative work in many speciality areas is supported by grants that totaled more than $11 million in 1985-86 and by national and industry-supported laboratories that make Cornell a center of research and development in this field.

Graduate study begins with work toward either the design-oriented professional M.Eng.(Electrical) degree or the research-oriented M.S. degree. Either program can lead to doctoral work, although the latter is the preferred route. Of the approximately 325 graduate students, about one hundred are Ph.D. candidates—a number large enough to achieve the critical mass that is conducive to effective research, yet small enough to enable the students and faculty to work together in close association. Both students and faculty members benefit also from interaction with people in related areas, such as physics, applied physics, applied mathematics, plasma studies, computer science, astronomy and space sciences, neurobiology and behavior, operations research, and mechanical and aerospace engineering.

More than fifty graduate-level courses are offered by the School of Electrical Engineering.

Facilities

Cornell offers state-of-the-art facilities for fundamental and applied research in many areas of electrical engineering. The University is host to the National Research and Resource Facility for Submicron Structures (NRRFSS), for example, and the laboratories are adjacent to the electrical engineering building. In addition, the University is one of the first three centers of excellence funded by the industrial Semiconductor Research Corporation for a program in VLSI microscience and technology. The Kettering Energy Systems Laboratory provides the most complete real-time model of a bulk power system in any university. The National Astronomy and Ionosphere Center in Puerto Rico is operated by Cornell for the National Science Foundation.

Interdisciplinary laboratories and programs include the Materials Science Center, the Laboratory of Plasma Studies, the Mathematical Sciences Institute, and the Center for Theory and Simulation in Science and Engineering (which includes a supercomputer).

Extensive computer facilities in the school augment those of the University. These school facilities include a local-area computer network consisting of a Data General MV-8000, a Harris H800, a DEC VAX 11/780, five AT&T 3B5s, and eighteen AT&T 3B2s. Two DEC VAX 11/750s, a Harris S-125, and a Harris S-123 are also available, as well as two DEC MicroVax IIs and several other dedicated minicomputers.

Areas of Research

Projects are in progress in the following areas of concentration:

Communications, Information, Decision Theory

Computer Engineering

Control and Systems Theory

Electromagnetic Theory and Applications

Electronic Circuits and Instrumentation

Energy Conversion and Power Systems

Integrated Circuits

Microwave Semiconductors: Circuits and Device Physics

Network and System Design

Plasma Physics and Applications

Quantum Electronics and Optical Physics

Radiophysics and Geophysical Plasmas

Semiconductor Materials for Electronic Devices

Signal Processing

Submicrometer Technology

Faculty Members and Their Research Interests

Venkat Anantharam, B.Tech. (Madras), M.S., M.A., Ph.D. (California, Berkeley): *queuing theory, communication networks, stochastic processes*

*Joseph M. Ballantyne, B.S., B.S.E.E. (Utah), Ph.D. (M.I.T.): *optoelectronic materials and devices, integrated optics, submicrometer lithography*

Toby Berger, B.E. (Yale), M.S., Ph.D. (Harvard): *information theory, signal processing, communication theory*

Ralph Bolgiano, Jr., B.S., B.E.E., M.E.E., Ph.D. (Cornell): *tropospheric radiophysics, structures of the lower and middle atmosphere*

Robert R. Capranica, E.E., B.S. (California, Berkeley), M.S. (New York University), Sc.D. (M.I.T.): *sensory communication, electrophysiological studies of neural processing, bioelectronics*

Herbert J. Carlin, B.S., M.S. (Columbia), D.E.E., Ph.D. (Polytechnic Institute of Brooklyn): *microwave circuits, network theory*

G. Conrad Dalman, B.E.E. (City College of New York), M.E.E., D.E.E. (Polytechnic Institute of Brooklyn): *millimeter and microwave solid-state devices and circuits*

David F. Delchamps, B.S. (Princeton), S.M., Ph.D. (Harvard): *linear and nonlinear dynamical systems, stochastic processes, estimation theory, control, system identification*

Lester F. Eastman, B.E.E., M.S., Ph.D. (Cornell): *microwave, optical, and high-speed optical solid-state devices, compound semiconductor growth by molecular-beam epitaxy and organometallic vapor-phase epitaxy*

Donald T. Farley, B.E.P., Ph.D. (Cornell): *ionospheric physics, space plasma physics, radar techniques*

**Bela G. Fejer, B.S. (São Paulo, Brazil), M.S. (CNAE—Comissão Nacional de Atividades Espaciais, Brazil), Ph.D. (Cornell): *space plasma physics and electrodynamics*

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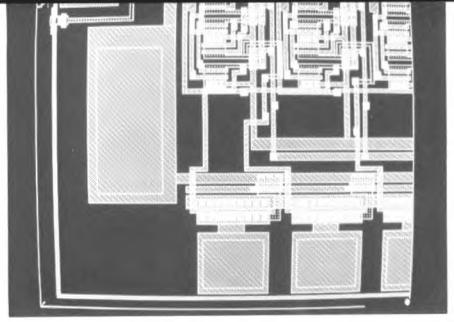
*University vice president; not accepting new graduate students at this time.

**An ad hoc member of the graduate faculty; may be nominated for membership on a graduate student's Special Committee by petition.



Terrence L. Fine, B.E.E. (City College of New York), S.M., Ph.D. (Harvard): *decision theory, estimation, foundations of probability*

Jeffrey Frey, B.E.E. (Cornell), M.Sc., Ph.D. (California, Berkeley): *physics of devices and materials for VLSI and for VLSI and submicron-scale electronics*

Tor Hagfors, Dipl.E.E. (Institute of Technology of Norway), M.S. (Trondheim), Ph.D. (Oslo): *radio physics, signal processing, ionospheric plasma, radio astronomy*

David A. Hammer, B.S. (California Institute of Technology), Ph.D. (Cornell): *plasma physics, nuclear fusion, high-power electron- and ion-beam physics and technology*

Chris Heegard, B.S., M.S. (Massachusetts, Amherst), Ph.D. (Stanford): *information theory, coding theory, digital communications, VLSI systems*

Lloyd W. Hillman, B.S. (Arizona), Ph.D. (Rochester): *nonlinear and quantum optics, laser theory, optoelectronics, integrated optics*

C. Richard Johnson, Jr., B.E.E. (Georgia Institute of Technology), M.S., Ph.D. (Stanford): *adaptive systems theory, digital processing, control theory*

Michael C. Kelley, B.S. (Kent State), Ph.D. (California, Berkeley): *space plasma physics, rocket and satellite instrumentation*

Myunghwan Kim, B.S. (Alabama), M.E., Ph.D. (Yale): *bioelectronics, control theory*

Paul M. Kintner, B.S. (Rochester), Ph.D. (Minnesota): *space plasma physics and plasma diagnostic instrumentation, microprocessor controls*

J. Peter Krusius, Dipl.Eng., Lic.Tech., D.Tech. (Helsinki University of Technology): *physics and technology of submicron devices and circuits*

Charles A. Lee, B.E.E. (Rensselaer), Ph.D. (Columbia): *solid-state physics and devices*

Richard L. Liboff, A.B. (Brooklyn College), Ph.D. (New York University): *transport in solid state and laboratory plasmas, properties of strongly coupled plasmas and neutral fluids*

Franklin T. Luk, B.S. (California Institute of Technology), M.S., Ph.D. (Stanford): *parallel computing, signal processing*

Noel C. MacDonald, B.S.E.E., M.S.E.E., Ph.D. (California, Berkeley): *electron spectroscopy, microfabrication, integrated circuits, particle-beam instrumentation*

James W. Mayer, B.S., Ph.D. (Purdue): *ion implantation in semiconductors, thin-film reactions, Rutherford backscattering and channeling, silicides, ion-beam modification of materials*

Paul R. McIsaac, B.E.E. (Cornell), M.S.E., Ph.D. (Michigan): *electromagnetic theory, microwave circuits and devices*

John A. Nation, B.Sc., Ph.D. (Imperial College, London): *plasma physics, high-energy electron and ion beams, accelerator physics*

Benjamin Nichols, B.E.E., M.E.E. (Cornell), Ph.D. (Alaska): *cable television systems, educational techniques*

Thomas W. Parks, B.E.E., M.S., Ph.D. (Cornell): *digital signal processing, seismic signal processing, circuit theory*

Clifford R. Pollock, B.S., M.S., Ph.D. (Rice): *lasers, molecular spectroscopy, quantum electronics*

Christopher Pottle, B.E. (Yale), M.S., Ph.D. (Illinois): *computer-aided design, power-system simulation, parallel computer processing, network theory*

Anthony P. Reeves, B.Sc., Ph.D. (Kent, Canterbury): *image processing, parallel computer architecture, pattern recognition*

Charles E. Seyler, B.A., M.A. (South Florida), Ph.D. (Iowa): *plasma physics, controlled thermonuclear fusion*

Ravindra N. Sudan, B.A. (Punjab, India), D.I.I.Sc. (Indian Institute of Science), D.I.C. (Imperial College, London), Ph.D. (London): *plasma physics, thermo-nuclear fusion, high-power electron- and ion-beam physics*

**Wesley E. Swartz, B.S. (Drexel), M.S., Ph.D. (Pennsylvania State): *ionospheric physics, radiophysics, computer systems, signal processing*

Chung L. Tang, B.S. (Washington), M.S. (California Institute of Technology), Ph.D. (Harvard): *lasers, quantum electronics, semiconductor materials and devices, ultrafast optical processes*

Robert J. Thomas, B.S.E.E., M.S.E.E., Ph.D. (Wayne State): *control and analysis of linear and nonlinear systems with applications to power systems*

James S. Thorp, B.E.E., M.S., Ph.D. (Cornell): *applications of optimization and control theory to power systems, robotics*

Hwa-Chung Torng, B.S. (National Taiwan), M.S., Ph.D. (Cornell): *computer engineering, computer networks, telecommunications, VLSI digital systems*

Norman M. Vrana, B.E.E. (New York University), M.E.E. (Cornell): *digital systems, central-processor design, microprocessor systems*

Charles B. Wharton, B.S., M.S. (California, Berkeley): *plasma physics, plasma diagnostics, high-power microwaves*

Edward D. Wolf, B.S. (McPherson), Ph.D. (Iowa State): *microminiaturization engineering, electron- and ion-beam instrumentation and processes*

George J. Wolga, B.E.P. (Cornell), Ph.D. (M.I.T.): *lasers, applied spectroscopy, semiconductor materials and devices*

S. Simon Wong, B.E.E., B.M.E. (Minnesota), M.S.E.E., Ph.D. (California, Berkeley): *fabrication technology, integrated circuits, optoelectronics*

**David W. Woodard, B.S.E.E. (Princeton), M.S. (Rutgers), Ph.D. (Cornell): *compound semiconductor materials and microwave devices*

**Ronald C. Woodman, I.M.E. (Universidad Nacional de Ingeniería, Lima, Peru), M.S., Ph.D. (Harvard): *radio snf plasma physics, remote sensing of the upper atmosphere*

Further Information

The faculty welcomes inquiries about the graduate programs and research opportunities. These may be addressed to the Graduate Faculty Representative, Electrical Engineering, Cornell University, Phillips Hall, Ithaca, New York 14853-5401.

Geological Sciences

The geological sciences are currently experiencing a period of major new insights, demands, developments, and growth. Geologists are confronted with urgent problems of mineral and energy resources and with geological hazards such as earthquakes and volcanic eruptions. They are challenged by the wealth of new information gained through exploration of the moon, the planets, and the oceans. They are stimulated by the emergence of the concept of plate tectonics to provide a framework for understanding many previously unexplained geological phenomena.

Cornell has responded to the rapid developments in the geological sciences by expanding its department, establishing an ambitious program of research, and providing a new, specially designed building. In little more than a decade, Cornell has achieved a leadership position in the field.

Approximately sixty graduate students are enrolled in M.S. and Ph.D. programs. Major fields of study include geobiology, paleontology and stratigraphy, geochemistry, mineralogy, petrology, geomorphology, geophysics, geotectonics and structural geology, marine geology, and seismology. In all areas there is a strong emphasis on application of the basic sciences to an understanding of the earth and on learning through participation in research projects. A graduate student may be involved primarily in field studies, or in theoretical work requiring analysis mathematics or a computer, or in laboratory studies that use sophisticated instruments. The opportunities for research and study are varied and expanding, and the outlook is global in scope.

Many kinds of careers are available to geologists. Possible employers include the energy and mineral industries, environmental and engineering firms, many branches of the federal and state governments, and educational institutions. Because of this diversity, the Field of Geological Sciences at Cornell seeks graduate students with a variety of interests and backgrounds. Previous training in geology is not required of applicants who have strong backgrounds in the basic sciences or in engineering.

Facilities

Snee Hall, the new geological sciences building, provides modern research facilities in all areas of the discipline. Special laboratories include those for geochemistry, geophysics, rock deformation, petrography, and paleontology. A wide variety of specialized equipment and peripheral facilities such as darkrooms and an instrument shop are available.

Beyond the campus, "laboratories" for Cornell geologists extend to areas around the world. Recent field projects have been carried out in Indonesia, the Philippines, Fiji and the New Hebrides, the Aleutian Islands, Greenland, the Rhine graben, the Scottish highlands, Ireland, South America, and many parts of the United States and Canada. Graduate students also participate in cruises on oceanographic research vessels.

Areas of Research

The major unifying themes of research activity are plate tectonics and continental evolution. These concepts are being explored and developed through their relation to economic geology, geodesy, geomorphology, gravimetry, paleontology, petroleum geology, petrology, rock mechanics, sedimentology, seismology, structural geology, stratigraphy, and other specialized areas.

Cornell is especially recognized for its leadership in the study of the geological structure of the continental crust, using seismic reflection techniques developed by the oil industry. Cornell is the operating institution in a major research project conducted by the Consortium for Continental Reflection Profiling (COCORP), a group of universities, companies, and government agencies. Graduate students have the opportunity to participate in the fieldwork, which involves the use of truck-mounted vibrators to generate seismic waves, and in the data-processing and data-interpretation phases of the project.

The variety of opportunities in geological sciences at Cornell is suggested by the following listing of faculty research interests.

Faculty Members and Their Research Interests

Richard W. Allmendinger, B.A. (Cornell), Ph.D. (Stanford): *structural geology, tectonics, micro- and mesoscopic rock fabrics, interpretation of seismic reflection profiles*

Muawia Barazangi, B.S. (Damascus), M.S. (Minnesota), Ph.D. (Columbia): *seismology, tectonics, geophysics*

William A. Bassett, B.A. (Amherst), M.A., Ph.D. (Columbia): *optical microscopy; x-ray diffraction; light absorption; light scattering and electrical resistance at high pressures and temperatures, studied through laser heating in diamond cells*

John M. Bird, B.S. (Union), M.S., Ph.D. (Rensselaer): *geotectonics, plate tectonics, orogeny, economic geology, ophiolites, origin of terrestrial metals, geology of the Appalachians, paleostress indicators*

Arthur L. Bloom, B.A. (Miami University), M.A. (Victoria, New Zealand), Ph.D. (Yale): *geomorphology, Quaternary tectonics and sea-level changes, Holocene sea-level changes, coastal geomorphology, glacial geomorphology and stratigraphy, denudation rates, planetary surfaces*

Larry D. Brown, B.S. (Georgia Institute of Technology), Ph.D. (Cornell): *exploration seismology, deep structure of continental crust, recent crustal movements, digital signal processing, computer graphics*

John L. Cisne, B.A. (Yale), Ph.D. (Chicago): *invertebrate paleontology, population and community paleoecology, biostratigraphy*

Bryan L. Isacks, A.B., Ph.D. (Columbia): *seismology and tectonics*

Teresa E. Jordan, B.S. (Rensselaer Polytechnic Institute), Ph.D. (Stanford): *stratigraphy and sedimentology, continental basin evolution, tectonics*

Daniel E. Karig, B.Sc., M.Sc. (Colorado School of Mines), Ph.D. (Scripps): *marine geology and geophysics, structural geology of orogenic belts, marginal basins, geomechanics*

Sidney Kaufman, A.B., Ph.D. (Cornell): *exploration geophysics, structure of the deep crust and upper mantle, geothermal resource development*

Robert W. Kay, A.B. (Brown), Ph.D. (Columbia): *petrology, geochemistry, application of trace-element and isotope geochemistry to the origin of igneous rocks and the lower crust*

David L. Kohlstedt, B.S. (Valparaiso), Ph.D. (Illinois): *high-temperature plasticity of rocks and minerals, study of stress levels along faults, electron microscopy of defects in minerals*

Arthur F. Kuckes, B.S. (M.I.T.), Ph.D. (Harvard): *geophysics, geomagnetism, electrical-conductivity distribution in the earth and moon, analysis of crustal flexure and gravity*

Fred H. Kulhawy, B.A., Ph.D. (California, Berkeley): *soil-structure interaction, rock engineering, finite-element modeling, marine and coastal geotechnique, geomechanics*

George H. Morrison, B.A. (Brooklyn College), M.A., Ph.D. (Princeton): *analytical geochemistry, trace-element abundances, ion-microprobe studies*

Jack E. Oliver, B.A., M.A., Ph.D. (Columbia): *geophysics, seismology, geotectonics, recent vertical movements, deep-crustal reflection studies*

Thomas D. O'Rourke, B.S. (Cornell), M.S., Ph.D. (Illinois): *soil-structure interaction, analytical methods, underground structures, geotechnical instrumentation*

Frank H. T. Rhodes, B.Sc., Ph.D. (Birmingham, England): *invertebrate paleontology, stratigraphy, history and philosophy of geology, conodont biostratigraphy*

Andy L. Ruina, Sc.B., M.S., Ph.D. (Brown): *friction laws and instabilities, geomechanics*

Arthur L. Ruoff, B.S. (Purdue), Ph.D. (Utah): *properties of materials at pressures above 1 megabar, plastic flow phenomena, synthesis of metallic hydrogen*

Carl E. Sagan, A.B., S.B., S.M., Ph.D. (Chicago): *physics and chemistry of planetary atmospheres and surfaces, spacecraft results, planetary geomorphology*

William B. Travers, B.S., M.S. (Stanford), Ph.D. (Princeton): *structural geology, tectonics, petroleum geology*

Donald L. Turcotte, B.S. (California Institute of Technology), M.Aero. E. (Cornell), Ph.D. (California Institute of Technology): *geophysics, geomechanics, mantle convection, convection in porous media*

Joseph Veverka, B.S., M.S. (Queens), M.A., Ph.D. (Harvard): *planetology, interpretation of spacecraft imagery, physics and morphology of planetary and satellite surfaces*

William M. White, B.A. (California, Berkeley), Ph.D. (Rhode Island): *isotope and trace element geochemistry of oceanic igneous rocks and marine sediments; solid-source mass spectrometry; chemical evolution of the mantle and crust*

Further Information

Questions about the graduate program may be addressed to William A. Bassett, Graduate Faculty Representative, Geological Sciences, Cornell University, Snee Hall, Ithaca, New York 14853-1504.

Materials Science and Engineering

The graduate Field of Materials Science and Engineering at Cornell provides the opportunity to students with widely different backgrounds to undertake research and study in the area of materials. The approximately sixty-five graduate students now enrolled have undergraduate degrees in physics or applied physics and in mechanical, metallurgical, chemical, and electrical engineering, as well as in materials science.

Much of the research is conducted in connection with the interdisciplinary Materials Science Center, the largest such university center supported by the federal government. This center makes available to faculty members and students a variety of modern and often very expensive equipment, and it provides financial assistance for graduate students through research assistantships. The materials science and engineering faculty also cooperates closely with the National Research and Resource Facility for Submicron Structures (NRRFSS) and with the Cornell High Energy Synchrotron Source (CHESS).

In addition to research-oriented M.S. and Ph.D. programs, a one-year professional M.Eng.(Materials) degree program is available.

Facilities

The extensive facilities available at Cornell make possible a variety of research in materials science. For example, a 50,000-pound electro-hydraulic materials-testing system enables researchers to study the macroscopic mechanical behavior of materials. In other kinds of investigation, the properties of materials can be probed down to the atomic scale. The instruments available include electron microscopes, electron scanning microscopes, field-ion microscopes, microprobes, x-ray diffraction equipment with a high-intensity source, low-energy electron diffraction and Auger spectroscopy apparatus, mass spectrometers, ultrasonic equipment, cryostats, ultrahigh-vacuum apparatus, high-pressure systems, r.f. sputtering equipment, Rutherford backscattering apparatus, and numerous pieces of optical and electronic equipment.

Areas of Research

A wide range of research projects is available to graduate students. Faculty members are continually developing new areas of research; for example, during the past few years projects were started on catalysis, ceramic oxides, amorphous materials, biomaterials, silicon for solar cells, materials for energy storage, and laser holography. The major areas are:

Imperfections in Solids
Surfaces, Interfaces, and Thin Films
Mechanical Behavior of Materials
High-Pressure Studies
Phase Transformations
Ceramic and Geologic Materials
Electrical and Magnetic Properties
Electron Microscopy
Submicron Research
Polymeric Materials Science

The following listing of faculty members and their research interests gives an idea of specific projects in progress or topics that are possible for graduate thesis research.

Faculty Members and Their Research Interests

Dieter Ast, Dipl.Phys. (Stuttgart), Ph.D. (Cornell): *amorphous materials, defects in semiconductors, metallic glasses*

William A. Bassett, B.A. (Amherst), M.A., Ph.D. (Columbia): *crystalline materials at high pressures, x-ray diffraction, Brillouin scattering*

Boris W. Batterman, B.S. Ph.D. (M.I.T.): *x-ray and neutron diffraction, synchrotron radiation, solid-state physics*

John M. Blakely, B.S., Ph.D. (Glasgow): *surface science, catalysis, photographic materials*

Clive B. Carter, B.A., M.A. (Cambridge), M.Sc. (London), Ph.D. (Oxford): *electron microscopy of ceramics, semiconductors*

Claude Cohen, B.S. (American University, Cairo), Ph.D. (Princeton): *transport phenomena, light scattering, polymeric materials*

David T. Grubb, B.A., M.A., Ph.D. (Oxford): *electron microscopy of polymers, radiation damage, mechanical properties of polymers*

Edward W. Hart, B.S. (City College of New York), Ph.D. (California, Berkeley): *theory of the mechanical behavior of solids, thermodynamics of interfaces*

Herbert F. Johnson, B.S., M.S., Ph.D. (Case): *gases in metals, cyclic deformation, environment and fracture*

David L. Kohlstedt, B.S. (Valparaiso), Ph.D. (Illinois): *ceramic materials, electron microscopy, physics of geological materials*

Edward J. Kramer, B.Ch.E. (Cornell), Ph.D. (Carnegie-Mellon): *superconductivity, mechanical properties, high-polymer physics*

Che-Yu Li, B.S.E. (Taiwan College of Engineering), Ph.D. (Cornell): *mechanical behavior, irradiation effects*

James W. Mayer, B.S., Ph.D. (Purdue): *ion implantation in semiconductors, thin-film reactions, Rutherford backscattering and channeling*

Robert Merrill, Chem.E. (Cornell), Sc.D. (M.I.T.): *chemistry and physics of surfaces, catalysis, corrosion, atomic and molecular scattering*

Christopher Ober, B.Sc. (Waterloo, Ontario, Canada), M.S., Ph.D. (Massachusetts): *polymer synthesis, optical microscopy, differential scanning calorimetry*

S. Leigh Phoenix, M.S. (Guelph), Ph.D. (Cornell): *mechanical reliability, statistical failure of materials*

Rishi Raj, B.Sc. (Newcastle upon Tyne, England), M.S., Ph.D. (Harvard): *processing and mechanical behavior of ceramics and metallic materials*

Thor N. Rhodin, B.S. (Haverford), A.M., Ph.D. (Princeton): *physics and chemistry of solid surfaces, electron properties of metals and alloys*

Arthur L. Ruoff, B.S. (Purdue), Ph.D. (Utah): *ultra-pressure phenomena, hot isostatic compaction, mechanical properties, reactive ion-beam etching*

Stephen L. Sass, B.Ch.E. (City College of New York), Ph.D. (Northwestern): *grain-boundary structure, phase transformations, transmission electron microscopy, diffraction techniques*

Benjamin M. Siegel, B.S., Ph.D. (M.I.T.): *ion-beam lithography for nanometer structuring and device fabrication, charged-particle optics, field-ionization sources, computer image processing*

John Silcox, B.Sc. (Bristol), Ph.D. (Cambridge): *electron microscopy, spectroscopy, diffraction*

Floyd O. Slate, B.S., M.S., Ph.D. (Purdue): *concrete, engineering materials*

Michael O. Thompson, B.S. (California Institute of Technology), Ph.D. (Cornell): *electronic properties of thin layers, rapid thermal processing, phase transformations, high-velocity crystal growth*

Watt W. Webb, B.S., Sc.D. (M.I.T.): *biological physics, fluctuations and cooperative phenomena in solids and liquids, physical optics*

Edward D. Wolf, B.S. (McPherson), Ph.D. (Iowa State): *microminiaturization science and technology*

Further Information

Inquiries about graduate study may be addressed to Rishi Raj, Graduate Faculty Representative, Materials Science and Engineering, Cornell University, Bard Hall, Ithaca, New York 14853-1501.

Mechanical Engineering

The broad program of graduate work in the Field of Mechanical Engineering covers the major technological branches of the discipline: mechanical systems, design, manufacturing, bioengineering, fluid mechanics, combustion, and heat transfer. Computer-assisted design, control, and analysis are emphasized in all these areas; an example is research on CAD/CAM.

The extensive course offerings in mechanical engineering are supplemented by offerings from aerospace engineering, operations research and industrial engineering, and theoretical and applied mechanics. There is particularly close cooperation with aerospace engineering, a discipline that is combined with mechanical engineering in the Sibley School of Mechanical and Aerospace Engineering. A weekly colloquium and various research conferences are held jointly with the graduate Field of Aerospace Engineering.

The vigorous research programs, supported by government and industry, address important contemporary engineering problems and seek to obtain a fundamental understanding of these problems and their solutions. Stimuli for research come from a variety of sources, including faculty consulting and cooperative programs with government and industry. Graduate students have a primary role in conducting this research.

Candidates for the M.S. and Ph.D. degrees select as their major area of study one of seven areas of concentration, listed below under Areas of Research. In addition, students select one minor area of concentration for the M.S. degree or two minor areas for the Ph.D. Minor subjects are generally chosen from a field other than mechanical engineering, such as mathematics, physics, theoretical and applied mechanics, or aerospace, electrical, or nuclear engineering. Programs of study are individualized, and graduate students and faculty members develop close working relationships.

A professional graduate program leading to the degree of M.Eng. (Mechanical) is also offered. Normally completed in two semesters, this is a curricular program emphasizing advanced course work and design practice.

About ninety students are currently enrolled in the graduate programs in mechanical engineering.

Facilities

Research and instruction are supported by up-to-date equipment in all the many areas of mechanical engineering. A partial list includes numerically controlled machine tools, an industrial robot, injection-molding equipment, high-powered lasers, combustion diagnostics equipment, hot-wire and laser anemometry equipment, and a number of wind tunnels. The Sibley School has extensive computer facilities, including an IBM 4341 mainframe computer; numerous graphics and interactive terminals; software for graphics, CAD/CAM, and analysis; PDP 11/34 and VAX 11/750 minicomputers; software for experimental data acquisition and analysis; and a number of microcomputers and microprocessors. In addition to facilities in the Sibley School, faculty members and graduate students have access to other resources throughout the University, notably the outstanding library system and the University's network of computers.

Off-campus facilities are also used. Thesis work may be carried out at the Brookhaven National Laboratory, for example. Research in biomechanics is facilitated by cooperative arrangements with the Hospital for Special Surgery in New York City. Research or design projects in manufacturing engineering often make use of industrial facilities.

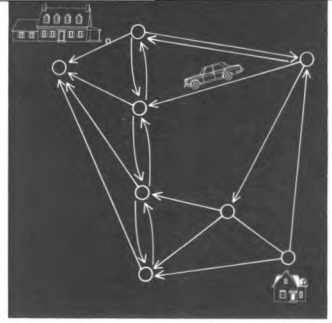
Areas of Research

Thesis and project work is organized within several areas of concentration:

Biomechanical Engineering
Combustion
Fluid Mechanics
Heat Transfer
Materials and Manufacturing Engineering
Mechanical Systems and Design
Power and Energy Systems

Specific research programs give an idea of the scope and significance of the research in the Sibley School. Current topics include aerodynamics of compressors and turbines, experimental studies and modeling of turbulent mixing and momentum transport processes, dynamics of vortex flows, computational fluid mechanics, boiling heat transfer, natural convection, flows in packed beds, experimental studies and modeling of turbulent combustion processes, droplet combustion, chemical kinetics, lubrication in joints and bearings, magnetic bearings, mechanical reliability, injection molding, rheology of polymers, polymer and metal welding methods, large-deformation forming processes, composite materials, robotics, computer-aided design, computer graphics, and orthopedic studies, including the design of prostheses.

An interdisciplinary activity in which mechanical engineering field members have a major share is the recently organized Cornell Manufacturing Engineering and Productivity Program, involving both University and industrial personnel and facilities.



Faculty Members and Their Research Interests

Peter L. Auer, A.B. (Cornell), Ph.D. (California Institute of Technology): *plasma physics, fusion power, energy policy analysis*

C. Thomas Avedisian, B.S. (Tufts), S.M. (M.I.T.), M.A., Ph.D. (Princeton): *heat transfer, boiling dynamics and superheated liquids, combustion*

Donald L. Bartel, B.S., M.S. (Illinois), Ph.D. (Iowa): *design optimization, computer-aided design, biomechanics*

John. F. Booker, B.E. (Yale), M.A.E. (Chrysler Institute), Ph.D. (Cornell): *hydrodynamic lubrication, finite-element methods, computer-aided simulation and design*

David A. Caughey, B.S.E. (Michigan), A.M., Ph.D. (Princeton): *fluid dynamics, transonic flow, computational aerodynamics*

Bart J. Conta, B.S. (Rochester), M.S. (Cornell): *thermodynamics, solar energy, technology and society*

Paul R. Dawson, B.S. (Montana State), Ph.D. (Colorado State): *materials and manufacturing engineering, finite-element methods, processes for forming and joining materials*

P. C. Tobias de Boer, Ir.(M.E.) (Delft, the Netherlands), Ph.D. (Maryland): *combustion processes, alternative fuels for combustion engines, high-temperature gasdynamics*

Albert R. George, B.S.E., A.M., Ph.D. (Princeton): *fluid dynamics, acoustics and noise control, aerodynamics, automotive engineering*

Frederick C. Gouldin, B.S.E., Ph.D. (Princeton): *combustion, fluid dynamics, air pollution, combustion spectroscopy*

Sidney Leibovich, B.S. (California Institute of Technology), Ph.D. (Cornell): *fluid dynamics, wave propagation, air-sea interactions*

Ming C. Leu, B.S. (National Taiwan), M.S. (Pennsylvania State), Ph.D. (California, Berkeley): *mechanical systems, automatic control, vibration and noise, robotics, manufacturing engineering*

Michel Y. Louge, Eng. (Ecole Centrale des Arts et Manufactures, Paris), M.S., Ph.D. (Stanford): *fluid beds, combustion, laser diagnostics*

John L. Lumley, B.A. (Harvard), M.S.E., Ph.D. (Johns Hopkins): *fluid dynamics, turbulence and turbulence modeling, geophysical turbulence, stochastic processes*

Franklin K. Moore, B.S., Ph.D. (Cornell): *fluid dynamics, energy systems, thermal pollution, turbomachinery*

Richard M. Phelan, B.S.M.E. (Missouri), M.M.E. (Cornell): *feedback control systems*

S. Leigh Phoenix, B.Sc., M.Sc. (Guelph), Ph.D. (Cornell): *mechanical reliability, probabilistic theories of material failure, composite materials, fracture mechanics*

Stephen B. Pope, B.Sc., Ph.D. (Imperial College, London): *combustion, turbulence, fluid mechanics, numerical methods*

Mark L. Psiaki, B.A., M.A., Ph.D. (Princeton): *manufacturing engineering, robotics, control systems, optimization*

Edwin L. Resler, Jr., B.S. (Notre Dame), Ph.D. (Cornell): *high-temperature gasdynamics, pollution control, ferrofluid mechanics*

Peter Schwartz, B.E., M.S. (Georgia Institute of Technology), M.A. (Pittsburgh), Ph.D. (North Carolina State): *composite materials, textile structures, random vibrations, stochastic processes*

Shan-Fu Shen, B.S. (National Central, China), Sc.D. (M.I.T.): *aerodynamics, computational fluid mechanics, polymer processing*

Dennis G. Shepherd, B.Sc. (Michigan): *fluid mechanics, turbo machinery, thermal and wind power*

Dean L. Taylor, B.S. (Oklahoma State), M.S., Ph.D. (Stanford): *vibrations, dynamics, mechanical systems and analysis, vehicle dynamics, computer methods*

Kenneth E. Torrance, B.S., M.S.M.E., Ph.D. (Minnesota): *heat transfer, computational fluid mechanics, geophysical heat transfer*

Herbert B. Voelcker, B.S., M.S. (M.I.T.), Ph.D. (Imperial College of Science and Technology, London): *manufacturing engineering, CAD/CAM, solid modeling, production automation*

Kuo-King Wang, B.S.M.E. (National Central, China), M.S.M.E., Ph.D. (Wisconsin): *manufacturing engineering, materials processing*

Zellman Warhaft, B.E. (Melbourne), Ph.D. (London): *experimental fluid mechanics, turbulence, micrometeorology*

Robert L. Wehe, B.S. (Kansas), M.S. (Illinois): *mechanical design, lubrication*

Further Information

Inquiries about the graduate degree programs should be addressed to the Graduate Faculty Representative, Mechanical Engineering, Cornell University, Upson Hall, Ithaca, New York 14853-7501.

Nuclear Science and Engineering

The graduate programs in the Field of Nuclear Science and Engineering at Cornell allow specialization in basic nuclear science, in applied nuclear engineering, or in a combination of thé two. Subjects of interest to faculty members include plasma and fusion technology, as well as the tradiational nuclear science and engineering topics.

Three graduate programs are offered. The M.Eng.(Nuclear) program is intended primarily for those who want a terminal professional degree, but it may also serve as preparation for doctoral study. The two-term curriculum covers the basic principles of nuclear reactor systems and places major emphasis on reactor safety and radiation protection and control. A design project is an important part of the M.Eng. program. The M.S. and Ph.D. programs are oriented toward research and require a thesis as well as course work. The major subject is either nuclear science or nuclear engineering, and minors may be in any related engineering or scientific field.

The appropriate preparation for graduate work in these programs is an undergraduate education in science, applied science, or engineering, with emphasis on mathematics and modern physics.

Facilities

The Ward Laboratory of Nuclear Engineering is the major facility at Cornell for graduate study and research in reactor physics and engineering, low-energy nuclear structure physics, nuclear and radiation chemistry, and fundamental atomic and molecular processes. Its facilities are used also by students and faculty members from other parts of the University for activation analysis, neutron radiography, and other nuclear techniques.

One of the major experimental facilities is a TRIGA reactor, a source of neutrons and gamma rays for activation analysis, neutron radiography, solid-state studies, and research in nuclear physics. It has a steady-state power of 500 kilowatts and a pulsing capability of up to 1,000 megawatts. A special feature is a rapid-transfer mechanism that allows study and use of radionuclides with relatively short half-lives. Another feature that is not available in other university research reactors in the United States is a neutron guide tube that provides a strong slow-neutron flux with almost no fast-neutron and gamma components. A neutron radiography facility for specimens up to 15 inches by 15 inches is a recent addition.

A critical facility, or "zero-power" reactor, unique to Cornell among universities, is used for basic studies in reactor physics and dynamics. Auxiliary equipment includes a pulsed 14-MeV neutron generator for studies of reactor transients.

A shielded gamma cell with a 10-kilocurie Co-60 source is used for studies of radiation chemistry and radiation damage.

Electron-beam ion sources (EBIS) are valuable new tools in atomic physics studies, with applications in plasma physics, astrophysics, and related areas. Cornell has several models that were developed at the Ward Laboratory.

Facilities available for research in fusion physics and technology include several intense ion-beam generators, Z-pinch and theta-pinch plasma devices, and a large collection of high-speed diagnostic instruments.

Also available for graduate research are special facilities operated by other departments or laboratories. Cornell's excellent central computing system is supplemented by minicomputers in the Ward Laboratory and in the Laboratory of Plasma Studies.

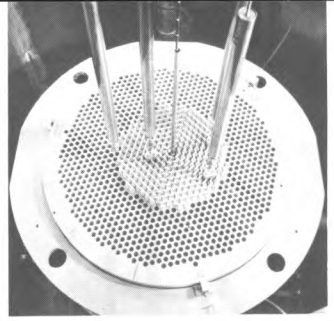
Areas of Research

Research subjects in nuclear science include low-energy nuclear structure physics, the interaction of atomic and nuclear processes, nuclear geochemistry and cosmochemistry, and activation analysis.

Subject areas in nuclear engineering include nuclear environmental engineering, reactor plant dynamics and safety, experimental and analytical reactor physics, neutron transport, radiation effects on materials, and radiation protection and control.

Topics for studies in fusion physics and technology, undertaken in coordination with ongoing research in other graduate fields, include applications of intense ion beams to fusion by inertial confinement and magnetic confinement.

Studies of atomic and molecular processes relevant to plasmas utilize EBIS sources and emphasize interactions of low-energy, very highly charged ions with atoms at keV energies.



Faculty Members and Their Research Interests

The graduate Field of Nuclear Science and Engineering comprises faculty members from a number of academic units. The departmental affiliations of the members are indicated.

K. Bingham Cady (Nuclear Science and Engineering, and Applied and Engineering Physics), S.B., Ph.D. (M.I.T.): *nuclear engineering, modeling of accident transients, nuclear reactor physics*

David D. Clark (Nuclear Science and Engineering, and Applied and Engineering Physics), A.B., Ph.D. (California, Berkeley): *nuclear-structure physics, nuclear instrumentation, radiation measurement*

Hans H. Fleischmann (Applied and Engineering Physics), Dipl.Phys., Dr.rer.nat. (Technical University, Munich): *thermonuclear power, plasma physics*

David A. Hammer (Nuclear Science and Engineering), B.S. (California Institute of Technology), Ph.D. (Cornell): *plasma physics, nuclear fusion, high-power electron- and ion-beam physics*

Bryan L. Isacks (Geological Sciences), A.B., Ph.D. (Columbia): *seismological aspects of nuclear power siting*

Vaclav O. Kostroun (Nuclear Science and Engineering, and Applied and Engineering Physics), B.Sc., M.Sc. (Washington), Ph.D. (Oregon): *interaction of radiation and matter, atomic physics*

Che-Yu Li (Materials Science and Engineering), B.S.E. (Taiwan College of Engineering, Ph.D. (Cornell): *nuclear materials, fast-neutron damage*

Franklin K. Moore (Mechanical and Aerospace Engineering), B.S., Ph.D. (Cornell): *thermal engineering, energy conversion*

George H. Morrison (Chemistry), B.A. (Brooklyn College), M.A., Ph.D. (Princeton): *nuclear geochemistry and cosmochemistry, activation analysis*

Mark Nelkin (Applied and Engineering Physics), B.S. (M.I.T.), Ph.D. (Cornell): *neutron scattering and transport*

James S. Thorp (Electrical Engineering), B.E.E., M.S., Ph.D. (Cornell): *systems engineering, controls*

Robert L. Von Berg (Chemical Engineering), B.S., M.S. (Washington), Sc.D. (M.I.T.): *radiation chemistry*

Additional faculty members available as advisers for M.Eng.(Nuclear) projects are:

Peter Gergely (Structural Engineering), P.E.; B.Eng. (McGill)., M.S., Ph.D. (Illinois): *seismic engineering*

John C. Thompson, Jr. (Physical Biology), B.S., M.S. (Virginia Polytechnic Institute), Ph.D. (Cornell): *environmental radiation biology*

Richard N. White (Structural Engineering), P.E.; B.S., M.S., Ph.D. (Wisconsin): *nuclear structural engineering*

Further Information

Further information may be obtained by writing to David D. Clark, Graduate Faculty Representative, Nuclear Science and Engineering, Cornell University, Ward Laboratory of Nuclear Engineering, Ithaca, New York 14853-7701.

Operations Research

The graduate Field of Operations Research at Cornell offers M.S. and Ph.D. degree programs and also a one-year program in operations research and industrial engineering that leads to the professional degree of M.Eng.(OR&IE). About seventy-five students, including thirty from foreign countries, are enrolled in these programs. Approximately one-third hold undergraduate degrees in mathematics; the others majored in an engineering or scientific discipline.

The M.S. and Ph.D. programs allow concentration in the areas of applied probability and statistics, manufacturing systems engineering, or optimization. The approach is highly analytical. Theories and techniques from mathematical programming, combinatorics, the theory of games, statistics, stochastic processes (queuing and inventory), scheduling, and simulation are developed and used extensively. Consideration is given to the construction of appropriate mathematical models to represent various real-life operations systems and to the development of techniques for analyzing the performance of these models. The ultimate goal of a student may be to make a fundamental contribution to the techniques of operations research, or it may be to apply such techniques to problems in any of a number of fields. Because the research is begun at an early stage, candidates who seek the doctorate are encouraged to apply for a Ph.D. program at the outset.

In the M.Eng.(OR&IE) program, the emphasis is on mathematical modeling and the application of quantitative techniques associated with optimization, probability, and statistics to the design and operation of systems. Students are required to complete an engineering project in which they have the opportunity to work closely with practicing engineers or analysts, as well as with Cornell faculty members.

An activity of interest to prospective graduate students is the Cornell Manufacturing Engineering and Productivity Program (COMEPP). Faculty members in the School of Operations Research and Industrial Engineering have a major part in this interdisciplinary venture, which involves industrial as well as University participants.

Facilities

Since research in this field is largely concerned with the planning and development of systems rather than with their implementation, the equipment needed for research is mainly for computing. The University and the School of Operations Research and Industrial Engineering are well provided with up-to-date computing facilities.

Cooperative arrangements and faculty contacts with industrial groups provide a real-world context for much of the research and project work.

Areas of Research

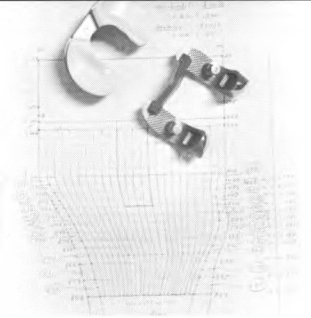
Thesis research and major course work are concentrated in one of three areas.

A concentration in *applied probability and statistics* focuses on techniques and underlying theory, particularly as these are applicable to engineering and scientific problems. The techniques emphasized fall into two main areas. One is applied stochastic processes, as in queuing, traffic, or inventory theory. The other area, statistics, includes statistical decision theory; statistical aspects of the design, analysis, and interpretation of experiments and of ranking and selection theory; reliability theory; and analysis of life data. A minor in mathematics or the equivalent is required.

The analysis and design of complex manufacturing and distribution systems are the central concerns in the area of *manufacturing systems engineering*. The problems studied include the establishment of inventory control policies in multi-stage production and distribution systems, the design of manufacturing plants, the planning and scheduling of production, and the economic analysis of engineering processes. Research activity may involve the development of new methodology and the application of computer science concepts. The research is often conducted directly with a cooperating manufacturing company.

Work in *optimization* traditionally consists of linear, nonlinear, integer, and combinatorial programming (including network flows and scheduling). Research in these areas ranges from the development and application of computational algorithms to associated studies of duality theory, convex analysis, polyhedra, combinatorics, and graph theory. Another aspect is game theory, the general study of conflict and cooperation, cost-allocation schemes, and voting procedures.

A student's minor may be another aspect of operations research or a subject offered by another school or department. Appropriate minor subjects include mathematics, computer science, econometrics and economic statistics, managerial economics, public-systems planning and analysis, and city and regional planning.



Faculty Members and Their Research Interests

Robert E. Bechhofer, A.B., Ph.D. (Columbia): *ranking and selection procedures, design of experiments, medical statistics*

Louis J. Billera, B.S. (Rensselaer), M.A., Ph.D. (City University of New York): *combinatorics, game theory*

Robert C. Bland, B.S., M.S., Ph.D. (Cornell): *network flows, graph theory, mathematical programming*

Eugene B. Dynkin, Cand.Sci., D.Sc. (Moscow): *probability theory, mathematical economics*

David C. Heath, A.B. (Kalamazoo), M.A., Ph.D. (Illinois): *applied probability*

Peter L. Jackson, B.A. (Western Ontario), M.S., Ph.D. (Stanford): *stochastic models, finance*

Walter R. Lynn, B.S.C.E. (University of Miami), M.S.C.E. (North Carolina), Ph.D. (Northwestern): *environmental systems*

William L. Maxwell, B.M.E., Ph.D. (Cornell): *scheduling, materials handling, simulation, manufacturing*

Joseph Mitchell, B.S., M.S. (Carnegie-Mellon), M.S., Ph.D. (Stanford): *applied optimization and probability*

John A. Muckstadt, A.B. (Rochester), M.S., M.A., Ph.D. (Michigan): *inventory and production control, logistics, manufacturing systems*

Narahari U. Prabhu, B.A. (Madras), M.A. (Bombay), M.Sc. (Manchester): *stochastic processes, queuing and storage theory*

Robin Roundy, B.S., M.S. (Brigham Young), Ph.D. (Stanford): *analytical management of production/inventory systems*

Thomas J. Santner, B.S. (Dayton), M.S., Ph.D. (Purdue): *reliability and survival analysis, discrete data, selection and ranking*

Lee W. Schruben, B.S. (Cornell), M.S. (North Carolina), Ph.D. (Yale): *applied operations research, health systems*

Frank L. Spitzer, B.A., M.A., Ph.D. (Michigan): *probability theory*

Howard M. Taylor 3d, B.M.E., M.I.E. (Cornell), Ph.D. (Stanford): *applied probability*

Michael J. Todd, B.A. (Cambridge), Ph.D. (Yale): *mathematical programming*

Leslie E. Trotter, Jr., A.B. (Princeton), M.S. (Georgia Institute of Technology), Ph.D. (Cornell): *mathematical programming*

Bruce W. Turnbull, B.A. (Cambridge), M.S., Ph.D. (Cornell): *biomedical statistics, quality control, reliability theory*

Lionel I. Weiss, B.A., M.A., Ph.D. (Columbia): *statistical decision theory, nonparametric statistics*

Further Information

Inquiries about graduate programs may be addressed to William L. Maxwell, Graduate Faculty Representative, Operations Research, Cornell University, Upson Hall, Ithaca, New York 14853-7501.

Theoretical and Applied Mechanics

Mechanics is the study of the motion and deformation of solids and fluids using mathematical analysis, modeling, and experimental observation. Athough its historical roots are deep, mechanics is a particularly modern subject because it is basic to so many areas of contemporary technology.

The graduate Field of Theoretical and Applied Mechanics at Cornell offers students a broad and fundamental education in the mechanics of rigid and deformable bodies (solids and fluids), applied mathematics at an advanced level, and modern experimental techniques. Graduates are prepared to carry out analytical or experimental research of high quality and to handle many engineering problems of an interdisciplinary nature.

The faculty is characterized by an interdisciplinary approach. Many are members of other graduate fields, such as Astronomy and Space Sciences, Mathematics, Materials Science and Engineering, Aerospace Engineering, and Agricultural Engineering. Many are members of University research centers: the Materials Science Center, the Center for Applied Mathematics, the Center for Radiophysics and Space Research, and the Laboratory of Plasma Studies.

The field has between thirty and thirty-five graduate students, who have a variety of academic and geographic backgrounds. They choose a specialty field from those listed under Areas of Research, and a minor from some other discipline such as aerospace engineering, applied mathematics, applied physics, astronomy, electrical engineering, geophysics, mathematics, mechanical engineering, physics, or structural engineering.

Facilities

The Department of Theoretical and Applied Mechanics has laboratories well equipped for experimental work in stress analysis, vibrations, ultrasonics, magnetoelastic interactions, and inelastic deformation of materials. Various facilities for materials processing, available through the Materials Science Center, can be used by students interested in such aspects of the mechanics of materials as fracture, creep and relaxation, cyclic loading and fatigue, and deformation at high temperatures or pressures.

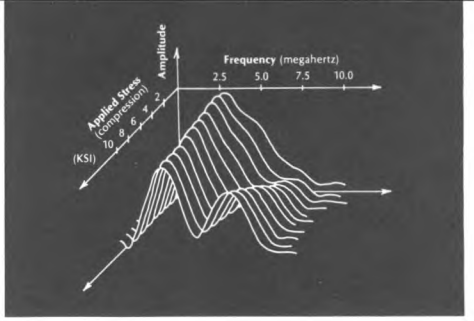
Extensive computer facilities, including equipment for graphics and computer algebra, are available.

Areas of Research

The major areas of study and research are:

Solid Mechanics
Fluid Mechanics
Dynamics and Space Mechanics
Biomechanics and Biomathematics
Mechanics of Materials

Current research activities are in the following areas: nondestructive evaluation of materials, magneto-elasticity, combustion, nonlinear dynamics, planetary dynamics, geomechanics, biomechanics, elasticity and inelasticity, fracture, applied mathematics, elastic wave propagation, and modern computational mechanics, including modeling of manufacturing processes.



Faculty Members and Their Research Interests

Joseph A. Burns, B.S. (Webb), Ph.D. (Cornell): *planetary dynamics, celestial mechanics, natural satellite studies*

Harry D. Conway, B.S., Ph.D., D.S. (London), M.A., Sc.D. (Cambridge): *isotropic and anisotropic elasticity, plates and shells, lubrication*

John Guckenheimer, B.A. (Harvard), Ph.D. (California, Berkeley): *dynamical systems, bifurcation theory*

Edward W. Hart, B.S. (City College of New York), Ph.D. (California, Berkeley): *inelastic deformation, materials science, theoretical physics, fracture*

Timothy J. Healey, B.S. (Missouri), M.S., Ph.D. (Illinois): *nonlinear structural and solid mechanics, bifurcation theory, computational mechanics*

Philip J. Holmes, B.A. (Oxford), Ph.D. (Southampton): *nonlinear mechanics, dynamical systems, stability and bifurcation theory*

Chung-Yuen Hui, B.A. (Wisconsin), M.S., Ph.D. (Harvard): *fracture mechanics, high-temperature crack propagation, geomechanics*

James T. Jenkins, B.S. (Northwestern), Ph.D. (Johns Hopkins): *continuum mechanics, biomechanics*

Richard H. Lance, B.S. (Illinois), M.S. (Illinois Institute of Technology), Ph.D. (Brown): *engineering plasticity, numerical methods, inelastic behavior of solids*

Geoffrey S. S. Ludford, B.A., M.A., Ph.D., Sc.D. (Cambridge): *fluid mechanics, especially magnetohydrodynamics, combustion and related applied mathematics*

Francis C. Moon, B.S. (Pratt), M.S., Ph.D. (Cornell): *dynamics of solids, magneto-solid mechanics*

Subrata Mukherjee, B.Tech. (Indian Institute of Technology), M.S. (Rochester), Ph.D. (Stanford): *viscoelasticity, plasticity, creep, modeling of manufacturing processes, computational mechanics*

Yih-Hsing Pao, B.S. (National Taiwan), M.S. (Rensselaer), Ph.D. (Columbia): *vibrations and wave propagation in solids, elasticity, magnetoelasticity*

Richard H. Rand, B.E. (Cooper Union), M.S., Sc.D. (Columbia): *nonlinear vibrations, applied mathematics, computer algebra, biomechanics*

Andy L. Ruina, Sc.B., M.S., Ph.D. (Brown): *friction laws and instabilities, experimental and theoretical*

Wolfgang H. Sachse, B.S. (Pennsylvania State), M.S., Ph.D. (Johns Hopkins): *experimental mechanics, mechanics of materials, nondestructive testing, wave propagation and physical acoustics*

Further Information

Further information may be obtained by writing to Subrata Mukherjee, Graduate Faculty Representative, Theoretical and Applied Mechanics, Cornell University, Kimball Hall, Ithaca, New York 14853-1502.

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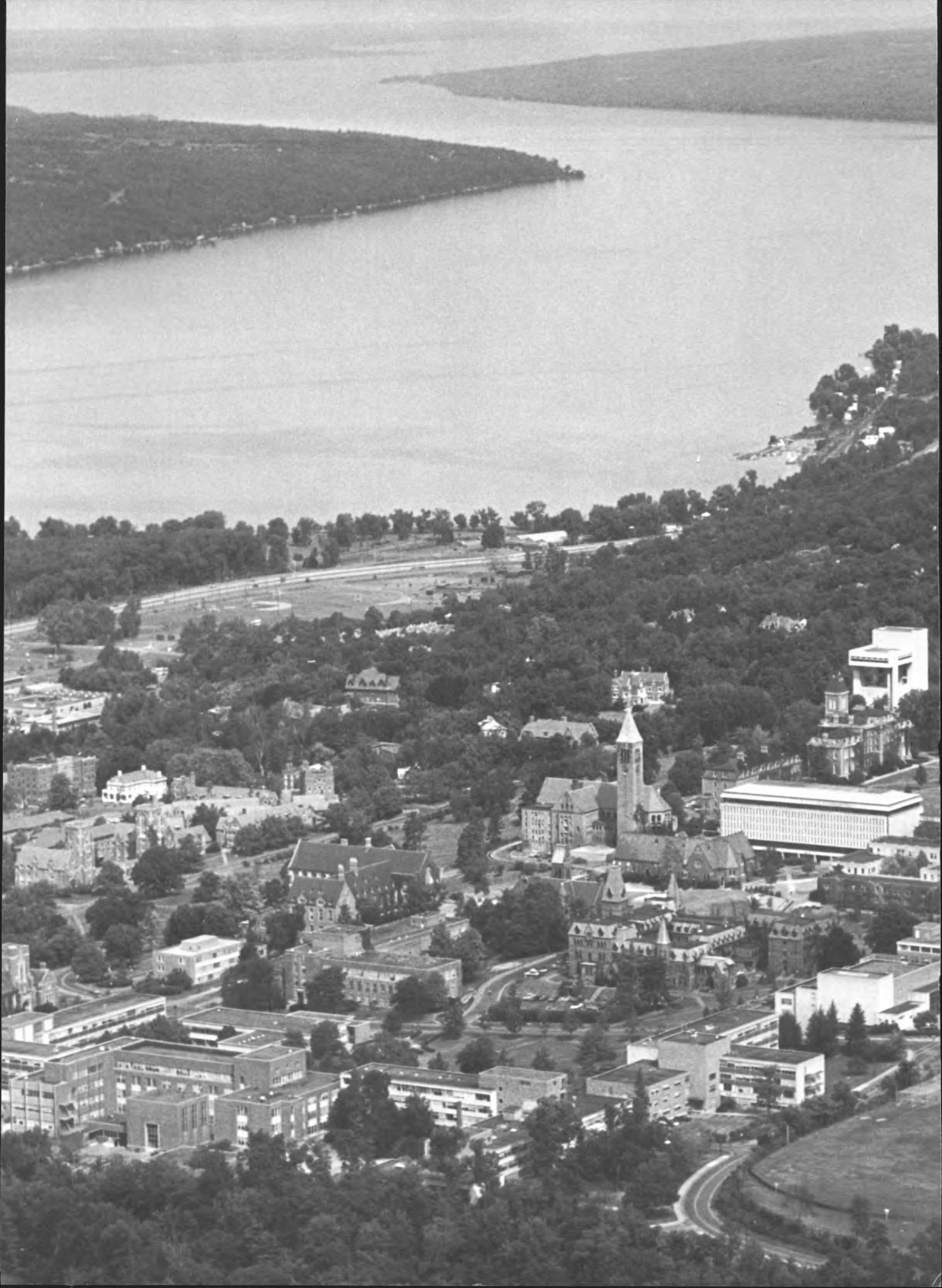

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