State University of New York

at Stony Brook

The Graduate School Bulletin

1963-1964

State University of New York

THE STATE UNIVERSITY OF NEW YORK was established by the State Legislature in 1948. It comprises 56 units: three university centers, two medical centers, a Graduate School of Public Affairs, 24 State colleges (18 four-year and 6 two-year), and 26 locally-sponsored community colleges. Although separated geographically, all are united in the purpose to improve and extend opportunities for youth to continue their education beyond high school.

State University offers programs in the liberal arts and sciences; engineering; home economics; industrial and labor relations; veterinary medicine; ceramics; agriculture; forestry; maritime service; teacher education; law; pharmacy; medicine; dentistry; social work and business administration. The University's two-year programs also include liberal arts study and a wide variety of technical courses in such areas as agriculture, business, and the industrial and medical technologies.

Advanced graduate study at the doctoral level is offered by the University at 12 of its units, including the university centers and the Graduate School of Public Affairs. While graduate work can be pursued at 23 of the colleges, the programs at the majority of these units are now limited to the master's level. The University, however, is continuing to broaden and expand overall opportunities for advanced degree study.

Governed by a Board of Trustees appointed by the Governor, State University of New York plans for the total development of State-supported higher education. Each college of State University is locally administered. Students should write directly to the institution in which they are interested for admission forms.

Although State University of New York is one of the largest state universities in the country, its students have the additional advantages of attending relatively small colleges.

The State University motto is: *"Let Each Become All He Is Capable of Being."*

STATE UNIVERSITY OF NEW YORK AT STONY BROOK

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The Graduate School Bulletin

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1963-1964

State University of New York

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(One appointment pending)

President of the University.....(Appointment pending)

Secretary of the University.....J. LAWRENCE MURRAY

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Calendar

Fall Semester 1963

Registration	September 24-25
Classes Begin	September 26
Thanksgiving Holidays	November 28-Dec. 1
Classes Resume	December 2
Christmas Holidays	December 22-January 5
Classes Resume	January 6
Semester Examinations Begin	January 23
Last Day of Semester	January 31

Spring Semester 1964

Registration	February 6-7
Classes Begin	February 10
Washington's Birthday (Holiday)	February 22 (Saturday)
Spring Holiday	March 23-31
Classes Resume	April 1
Final Examinations Begin	May 27
Memorial Day (Holiday)	May 30 (Saturday)
Last Day of Semester	June 6
Commencement	June 7

State University of New York at Stony Brook

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State University of New York at Stony Brook

Faculty

Karl D. Hartzell, *Administrative Officer*
Ph.D., Harvard, 1934

David Fox, *Acting Dean, Graduate School; Professor of Physics*
Ph.D., California (Berkeley), 1952

Stanley R. Ross, *Acting Dean, College of Arts and Sciences; Chairman, Department of History*
Ph.D., Columbia, 1951

Thomas F. Irvine, Jr., *Dean, College of Engineering; Professor of Engineering*
Ph.D., Minnesota, 1956

John M. Alexander, *Associate Professor of Chemistry*
Ph.D., Massachusetts Institute of Technology, 1956

Nandor L. Balazs, *Professor of Physics*
Ph.D., Amsterdam, 1951

Edwin H. Battley, *Associate Professor of Biology*
Ph.D., Stanford, 1956

†Ivan Bernal, *Assistant Professor of Chemistry*
Ph.D., Columbia, 1963

Robert S. Boikess, *Assistant Professor of Chemistry*
Ph.D., Columbia, 1961

Francis T. Bonner, *Professor of Chemistry*
Chairman, Department of Chemistry
Ph.D., Yale, 1945

Walter S. Bradfield, *Professor of Engineering*
Chairman, Department of Thermal Sciences
Ph.D., Minnesota, 1957

Albert D. Carlson, *Assistant Professor of Biology*
Ph.D., State University of Iowa, 1960

Robert D. Cess, *Associate Professor of Engineering*
Ph.D., Pittsburgh, 1959

**Sheldon S. L. Chang, *Professor of Engineering*
Chairman, Department of Electrical Sciences
Ph.D., Purdue, 1947

Robert Lee de Zafra, *Assistant Professor of Physics*
Ph.D., Maryland, 1958

Daniel Dicker, *Assistant Professor of Engineering*
D. Eng. Sc., Columbia, 1961

**Peter M. Dollard, *Assistant Professor of Engineering*
Ph.D., Polytechnic Institute of Brooklyn, 1963

Leonard Eisenbud, *Professor of Physics*
Ph.D., Princeton, 1948

Frank C. Erk, *Professor of Biology*
Chairman, Department of Biological Sciences
Ph.D., Johns Hopkins, 1952

Arnold M. Feingold, *Professor of Physics*
Ph.D., Princeton, 1952

Aaron Finerman, *Professor of Engineering*
Director, Computing Center
Sc. D., Massachusetts Institute of Technology, 1957

James Fowler, *Assistant Professor of Biology*
Ph.D., Columbia, 1961

John J. Gaudet, *Assistant Professor of Biology*
Ph.D., California (Berkeley), 1963

Irving Gerst, *Professor of Engineering*
Chairman, Department of Engineering Analysis
Ph.D., Columbia, 1947

Edward E. Gilbert, *Assistant Professor of Biology*
Ph.D., California (Berkeley), 1961

Theodore D. Goldfarb, *Assistant Professor of Chemistry*
Ph.D., California (Berkeley), 1959

***Joseph Jach, *Associate Professor of Engineering*
D.Phil., Oxford, 1955

Peter B. Kahn, *Assistant Professor of Physics*
Ph.D., Northwestern, 1960

Yi-Han Kao, *Assistant Professor of Physics*
Ph.D., Columbia, 1962

†C. William Kern, *Assistant Professor of Chemistry*
Ph.D., Minnesota, 1961

Edward M. Kosower, *Associate Professor of Chemistry*
Ph.D., California (Los Angeles), 1952

Sol Kramer, *Professor of Biology*
Ph.D., Illinois, 1948

*Edward D. Lambe, *Associate Professor of Physics*
Ph.D., Princeton, 1959

Paul C. Lauterbur, *Associate Professor of Chemistry*
Ph.D., Pittsburgh, 1962

Juliet Lee-Franzini, *Assistant Professor of Physics*
Ph.D., Columbia, 1960

William J. le Noble, *Assistant Professor of Chemistry*
Ph.D., Chicago, 1957

Arthur R. Lepley, *Assistant Professor of Chemistry*
Ph.D., Chicago, 1958

***Sumner N. Levine, *Professor of Engineering*
Chairman, Department of Material Sciences
Ph.D., Wisconsin, 1949

Robert W. Merriam, *Associate Professor of Biology*
Ph.D., Wisconsin, 1953

Richard A. Mould, *Associate Professor of Physics*
Ph.D., Yale, 1957

Herbert Muether, *Professor of Physics*
Ph.D., Princeton, 1951

Edward O'Brien, *Assistant Professor of Engineering*
Ph.D., Johns Hopkins, 1960

T. Alexander Pond, *Professor of Physics*
Chairman, Department of Physics
Ph.D., Princeton, 1953

Fausto Ramirez, *Professor of Chemistry*
Ph.D., Michigan, 1949

B. James Raz, *Associate Professor of Physics; Acting Assistant Dean, College of Arts and Sciences*
Ph.D., Rochester, 1955

***Robert Rosenberg, *Assistant Professor of Engineering*
Eng.Sc.D., New York University, 1961

Robert Schneider, *Assistant Professor of Chemistry*
Ph.D., Columbia, 1959

*Henry Silsbee, *Associate Professor of Physics*
Ph.D., Harvard, 1951

Robert E. Smolker, *Associate Professor of Biology*
Ph.D., Chicago, 1959

William T. Snyder, *Associate Professor of Engineering*
Ph.D., Northwestern, 1958

Richard Solo, *Assistant Professor of Chemistry*
Ph.D., California (Berkeley), 1962

Sei Sujishi, *Professor of Chemistry*
Ph.D., Purdue, 1949

Clifford E. Swartz, *Associate Professor of Physics*
Ph.D., Rochester, 1951

Bernard D. Tunik, *Associate Professor of Biology*
Ph.D., Columbia, 1959

George C. Williams, *Associate Professor of Biology*
Ph.D., California (Los Angeles), 1955

Armen H. Zemanian, *Professor of Engineering*
Sc.D., New York University, 1953

† *Appointment effective February, 1964.*
* *On leave until September, 1964.*
** *Participating in the graduate program of the Department of Engineering Analysis.*
*** *Participating in the graduate program of the Department of Thermal Sciences.*

General Information

At the beginning of the second year on its permanent campus, the State University of New York at Stony Brook has the mandate to award undergraduate and graduate degrees in all the major fields of the Humanities, Social Sciences, Natural Sciences, and Engineering, as facilities permit. Established as the first of the four major university campuses within the State University system, the Stony Brook campus is expected to enroll 10,000 to 20,000 students when fully developed; of this number it is expected that twenty-five to thirty percent will be graduate students.

Stony Brook Campus

The campus is situated in a wooded and hilly region of the North Shore of Long Island, on four hundred and eighty acres of land donated to the State of New York by Ward Melville. The region, which is commonly known as the Three Village area from the associated villages of Stony Brook, Setauket, and Old Field, is rich in historic landmarks and cultural facilities.

Graduate Programs

During the 1963-1964 academic year, graduate programs, leading to the Master's and Ph.D. degrees, are offered by the Departments of Chemistry and Physics of the College of Arts and Sciences and by the Departments of Thermal Sciences and Engineering Analysis in the College of Engineering. The Department of Biology will initiate a graduate program in September, 1964. Currently under consideration is a proposal to offer graduate work in Mathematics, starting in 1964. Proposals for programs in the Humanities and Social Sciences are now being prepared.

Buildings and Research Facilities

The capital commitment for the presently planned buildings is estimated to be in excess of $70,000,000. The subsequent addition of specialized Graduate Schools will undoubtedly increase this amount substantially.

During 1963-1964, the following academic buildings are in use: Biology, Chemistry, Engineering, Humanities, Physics, and the Library. In addition, the campus has dormitories and dining halls, a Physical Education building and service buildings. In various stages of planning or construction are: a Social Science building, a Fine Arts center, a second Engineering building, an Earth and Space Science building, additional buildings or extensions for the departments in the natural sciences, a Central Communications and Lecture Hall building, an extension to the Library, an Administration building, a University Center, an Auditorium, an Infirmary, and additional dormitories.

The new Chemistry Building is a spacious, modern structure (83,000 sq. ft. gross floor area) designed for research and instructional activities covering a broad range of specialization in chemistry. Equipment available for research use includes nuclear magnetic resonance spectrometers, high resolution far infrared and infrared spectrometers, visible and ultraviolet spectrometers, Raman spectrometer, mass spectrometer, nuclear particle detection apparatus, electron spin resonance spectrometer, and optical rotatory dispersion equipment. In addition, such accessories as have become routinely essential in modern chemical research (e.g., gas chromatographs, high vacuum equipment, infrared and ultraviolet analytical instruments) are broadly included. Glass blowing and machine shop facilities also are available.

The new Biology Building, containing 86,000 sq. ft. of gross floor area, was occupied in the Fall of 1963. It is well designed and equipped for instruction and research in a number of areas of modern biology. Included in the building are a complete radiobiology laboratory, constant temperature rooms, an X-ray machine, controlled environment chambers, an electron microscope, a shop, and laboratories specially suited for work in biochemistry, physiology, genetics, cytology, ecology, microbiology, and animal behavior. Adjoining the main building are an air-conditioned animal wing with a marine aquarium room and a compartmented greenhouse for projects requiring various temperatures, humidities, and light conditions. Close to the building are the outdoor animal quarters for pigeons, doves, and small mammals.

The Biology Department has its own boat for use in marine research. Plans are under way to develop a shore station on Long Island Sound, near the campus, that will be used for instruction and research in marine biology.

The Physical Laboratory, completed in July of 1963, contains 76,000 square feet, of which more than one-third is for graduate instruction and faculty and graduate research. In addition to the usual departmental shop facilities (photographic, electronic, and machine shops) the initial equipping of the Laboratory includes experimental apparatus for research in low-temperature and solid-state physics, magnetic resonance, quantum electronics, beta- and gamma-ray spectroscopy. The Physics Department includes faculty members affiliated in research with Brookhaven National Laboratory; a portion of the experimental program is in instrumentation in nuclear and high energy physics for use at such nearby facilities. The faculty's activities in theoretical physics include nuclear theory, statistical mechanics, field theory, many-body problems, plasma physics, solid state physics and general relativity; research in these areas is aided by proximity to the University Computing Center.

An Engineering Building (containing 96,000 sq. ft of gross floor area) was completed in the Fall of 1963. During the initial period of occupancy, this building will be used for instruction and research, and will house the Computing Center. At a later date, the major research facilities and the Computing Center will be located in a Graduate Research Building, scheduled to be completed in 1965. The Engineering Building is equipped for the research of the Departments of Electrical Sciences, Engineering Analysis, Material Sciences, and Thermal Sciences; the latter department has apparatus for research in the areas of heat transfer (including free and forced convection, radiation, film boiling, and heat transfer in chemically reactive systems), turbulence and diffusive processes, combustion, energy conversion, magnetohydrodynamics, and irreversible thermodynamics. The facilities include a precision machine shop, faculty and student shops, and an electronics shop.

Library

The present library building has a 350,000-volume capacity and seats 750 readers; there are plans for an annex that will provide space for an additional 650,000 volumes. The building is equipped as an open-stack library, with carrels, study rooms, projection and music rooms, and areas for special materials. It offers a maximum of free access to the collections, together with a maximum of privacy, by scattering small seating areas throughout the stacks.

The number of subscriptions to journals in Physics, Chemistry, Biology, Engineering, and Mathematics is about 800 and is increasing rapidly. The library purchases the current books of interest to research workers in these fields; there is also an extensive program for the acquisition of older books. Books and photocopies of articles not presently available may be obtained through an efficient interlibrary loan service. Facilities for microfilm and microprint reading are available. For making reproductions, the library has a thermocopying machine and a microfilm reader-printer.

Computing Center

The services of the Computing Center of the College of Engineering are available to all faculty members and their graduate students. At present, the Center has an IBM 1620, with 60,000 positions of storage, and card input-output; peripheral equipment includes a printer, reproducer, interpreter, plotter, sorter, and several keypunch units.

Present plans call for the installation of an IBM 7040 computer and auxiliary equipment in the late spring of 1964. As the need for computer facilities increases, larger and faster equipment will be installed.

The Computing Center intends to build a staff of full-time professional programmers and graduate students who will furnish programming assistance to faculty members and their graduate students and carry out research in the various areas of the computational sciences.

Housing Accommodations

Single graduate students may live in the university residence halls. In 1963-64 housing for approximately 800 men and women will be available on the Stony Brook campus. All rooms provide for double occupancy; however, if space is available, a graduate student may have a room to himself.

Board is purchased by resident students each semester. Nonresident students may purchase meals in the university dining hall also.

Houses, apartments, and rooms are available within a reasonable driving distance of the university. It is somewhat difficult to obtain off-campus accommodations within walking distance.

Financial Information

Tuition

The tuition rate for graduate students is $20 per semester-hour. There is no tuition charge for university graduate assistants, but they pay the other fees listed below.

Other Fees

State University Fee: $1.75 per semester-hour.

Student Health and Accident Insurance: $22.50 per academic year.

Matriculation Fee: $5.00, paid at the time of admission.

Late Registration Fee: $2.00, paid by students who register after the official registration period.

Transcript Fee: $1.00 for each transcript. (A student who obtains a degree may receive two transcripts without charge.)

Residence Charges

Room and board charges for students living at the Stony Brook campus will be approximately $815-$830 per academic year, payable on a quarterly basis. A $25 advance deposit is required, and this amount is applied to the first quarter payment. The room deposit is not refundable after June 30. Each resident student pays approximately $25 per year for linen service.

Refunds

A student who withdraws after the first week of any semester is entitled to only a partial refund of monies collected. A schedule of refunds is available in the Business Office.

Financial Aid

Veterans may attend the State University under the benefits of Public Law 894 (disability) or 550 (Korean War).

Other sources of direct financial aid and loans include the Division of Vocational Rehabilitation of the New York State Education Department, the New York State Scholar Incentive Program, the

New York Higher Education Assistance Corporation, and the National Defense Education Act program. Information may be obtained from the Dean of Students.

Graduate Assistantships and Fellowships

Teaching assistanships are available, each with a stipend of $2,575 for the 1963-64 academic year, and with tuition exemption.

Research assistantships and fellowships are available for advanced graduate students.

Teaching assistantships, research assistantships and fellowships are awarded on a competitive basis by the Graduate School, on recommendation of the department.

Admission Requirements

To be admitted to graduate study, an applicant must have the preparation and apparent ability which (in the judgment of the department and the Graduate School) is sufficient to enable him to progress satisfactorily in a degree program. Admission decisions are based primarily on past records and on letters of recommendation. Ordinarily, a baccalaureate degree in the chosen field of study is required, with an average grade of B in course work in the major and related areas. However, in exceptional cases in which the undergraduate preparation is inadequate, or the grade average is less than B, an applicant may be admitted provisionally, if he is considered to have a reasonable probability of making satisfactory progress in graduate studies.

The department may set conditions which the admitted student must satisfy during the early period of his graduate work.

Admission application blanks may be obtained from the Office of the Graduate School, State University of New York, Stony Brook, Long Island, New York.

Degree Requirements

Admission to graduate school does not automatically qualify a student as a candidate for a degree. Advancement to candidacy may be recommended to the Graduate School by the department after a review of the student's performance in courses, individual study, and departmental examinations. A candidate for a degree engages in research, leading to a thesis. (For the master's degree, a department may substitute a comprehensive examination for the research and thesis.)

While individual departments may have certain course requirements, the Graduate School does not specify a minimum number of courses to be completed for each degree. Instead, the granting of the degree is based on the completion of residence, examination, thesis, and special departmental requirements, and the recommendation of the student's department. Ordinarily, however, certain courses should be taken in preparation for comprehensive examinations and research. The student will follow an approved program of courses, seminars, and individual study, determined so as to meet his needs and to satisfy departmental requirements. A student, well prepared on admission, should normally be able to complete the course work for the Master's degree in about one calendar year of full-time study, and for the Ph.D. preliminary (candidacy) examination in two to three years of full-time study.

The M.A. and M.S. Degrees

1. Residence: one year
2. Admission to candidacy
3. Research and thesis, or the passing of a comprehensive examination
4. Departmental recommendation

The Ph.D. Degree

1. Residence: two years
2. The passing of a proficiency examination in each of two languages

3. The passing of the departmental preliminary examination
4. Advancement to candidacy
5. Research and thesis (including oral defense of thesis)
6. Departmental recommendation

The Ph.D. thesis must demonstrate the ability of the candidate to carry on independent research of high quality and must represent a significant contribution to knowledge. The thesis material must be of such professional quality that it meets the publication standards of leading journals in the field.

Degree Programs and Courses

Courses numbered 201 to 399 are for advanced undergraduates; detailed descriptions of these courses are given in the Undergraduate Bulletin (which may be obtained by writing to the Admissions Office, State University of New York, Stony Brook, Long Island, New York). Graduate courses are numbered 401 and above. Odd-numbered courses are ordinarily given in the Fall, even-numbered courses in the Spring.

The following symbols are used for department names:

BIO — Biology
CHE — Chemistry
PHY — Physics
ESA — Engineering Analysis
ESM — Material Sciences
EST — Thermal Sciences

College of Arts and Sciences

Biology

Professors Erk (Chairman), Kramer; *Associate Professors* Battley, Merriam, Smolker, Tunik, Williams; *Assistant Professors* Carlson, Fowler, Gaudet, Gilbert.

Admission to Graduate Study

For admission to graduate study in biology the following are required:

A. A baccalaureate degree, with at least the following undergraduate preparation: four laboratory courses in biology totaling at least 16 semester credits, and including work in genetics and evolution, development, cytology or general physiology, and ecology; chemistry, including at least one semester of organic chemistry; one year of college physics; mathematics through the calculus; two years of a foreign language or equivalent proficiency.

B. A minimum grade-point average of 2.75 (B–) in all undergraduate course work, and 3.00 (B) in science and mathematics courses.

C. Acceptance by the Department of Biological Sciences and the Graduate School.

In special cases, students not meeting requirements (A) and (B) may be admitted on a provisional basis. Provisional students must act immediately to fulfill deficiencies in basic courses, the credits for which do not count toward graduate degree requirements.

Requirements for the M.A. Degree

A. Residence: one year

B. Qualification to candidacy

C. Formal course requirements: successful completion of an approved course of study, including Interarea Seminar; at least 24 semester credits, of which 18 credits shall be in graduate level courses, and of which 4 credits may be for research.

D. Thesis: Independent laboratory, field, or theoretical research under the supervision of a staff member of the Department.

E. Comprehensive examination: When the thesis is accepted, a comprehensive examination will be given no later than two weeks before the end of the semester in which the final work in the Master's program is done; the examination may include a defense of the thesis.

Requirements for the Ph.D. Degree

A. Residence: two years

B. First year program: During his first year of course work, the student participates in the Interarea Seminar both semesters. He also prepares a scholarly paper on a subject of his choice. The paper is presented to the Departmental Graduate Committee at least two weeks before the end of the first academic year. The Committee must reach consensus that the overall performance of the student during his first year has been satisfactory. (If a student has been working toward a Master's degree and wishes to proceed to the Ph.D. degree, his work and thesis will be evaluated to determine whether he may continue toward the higher degree.

C. Language: Reading knowledge of two foreign languages, selected usually from German, French and Russian, in consultation with the student's advisor.

D. Formal course requirements: Successful completion of an approved course of study.

E. Preliminary examination: After completing the major portion of course work and meeting his language requirement, the student may apply for the preliminary examination. The examination will test both the breadth of the student's knowledge and its depth within his chosen area of biology. The examination may be written or oral, or both; it may come as early as the fourth semester but not beyond the sixth semester of graduate work. In case the performance on the examination is not satisfactory, the examining committee may recommend further study and set a time for reexamination. No more than one reexamination may be given.

F. Advancement to candidacy: The Department's recommendation with respect to candidacy will be based on the satisfactory completion of the above requirements.

G. Research and thesis

H. Thesis examination: An examining committee will read the thesis and give the candidate an oral examination on the thesis research and related areas. Upon recommendation of the committee, the department chairman recommends acceptance or rejection of the thesis to the Graduate School.

Sample Programs

The following is a sample program leading to the M.A. degree in the area of behavioral physiology:

Semester I		Semester II	
Integrative mechanisms	4	Ethology	4
Experimental embryology	4	Physiological psychology	3
Comparative physiology	4	Physiological genetics	4
Interarea seminar	1	Interarea seminar	1

The following is a sample program leading to the Ph.D. degree in the area of cellular biology:

Semester I		Semester III	
Physical chemistry	3	Nuclear and radiochemistry	3
Experimental embryology	4	Genetics of microorganisms	3
Comparative physiology	4	Cellular biology	4
Interarea seminar	1	Research	2
Semester II		**Semester IV**	
Physical chemistry	3	Physiological genetics	3
Biochemistry	4	Population and community ecology	5
Seminar on molecular biology	3	Research	3
Interarea seminar	1		

The following is a sample program leading to the Ph.D. degree in the area of genetics:

Semester I		Semester III	
Probability and statistics	3	Integrative mechanisms	4
Physical chemistry	3	Cellular biology	4
Genetics of microorganisms	3	Research	3
Interarea seminar	1		
Research	2	**Semester IV**	
Semester II		Ethology	4
Physical chemistry	3	Population and community ecology	5
Biochemistry	4	Research	3
Physiological genetics	4		
Interarea seminar	1		

Courses

A. The following advanced undergraduate courses carry graduate credit.

BIO 341 *Integrative Mechanisms.* Fall semester. 4 hrs.

This course, which considers muscular physiology, neurophysiology, endocrinology, and sensory physiology, focuses upon the physiological mechanisms involved in animal behavior and the roles they play in coordinating and integrating the activities of organisms.

BIO 342 *Ethology.* Spring semester. 4 hrs.

A sequel to Biology 341, this course examines the behavioral activities of diverse groups of animals from the ethological, or comparative, standpoint. The evolution of inherited motor patterns which adapt organisms to their particular environments, and the relationships of such motor behavior to concepts in taxonomy, genetics and ecology, are emphasized.

BIO 353 *Experimental Embryology.* Fall semester. 3 hrs.

Animal development is examined from various theoretical points of view. Embryological phenomena are considered at the organismal, cellular, biochemical, and genetic levels. The experimental basis of contemporary theory is emphasized. Two hours lecture and discussion with 3 hours of laboratory.

BIO 358 *Physiological Genetics.* Spring semester. 4 hrs.

A course dealing with genic function from the molecular to the organismic level. The biochemical correlates of inheritance are studied as developmental consequences of gene actions. Topics considered include recombination, gene interactions, position and dosage effects, mutation, enzyme formation and role in development, modification of gene expression, cytoplasmic inheritance and the evolution of genic function. One lecture, two discussions, three hours of laboratory per week.

BIO 362 *Biochemistry.* Spring semester. 4 hrs.

A course designed to introduce the student to the chemistry of the major classes of compounds found in biological systems. Reactions and syntheses of these major classes are considered. Intermediate metabolism is emphasized with attention to the enzymatic, kinetic, and thermodynamic aspects. Laboratory work is designed to give the student actual experience with the tools and methods of biochemical work. Two hours of lecture and two three-hour laboratories per week.

BIO 372 *Marine Biology.* Spring semester. 4 hrs.

An introduction to the marine ecosystem with emphasis on the fishes of coastal and estuarine habitats. The demography, behavior, and physiological ecology of marine organisms are explored with relation to physical variables. Work in the field and laboratory will emphasize quantitative sampling of populations and standard oceanographic techniques in the collection of data. Discussions, laboratories and field work to be scheduled on Saturdays.

BIO 381 *Genetics of Microorganisms.* Fall semester. 3 hrs.

A presentation of methods and principles involved in studies of heredity in bacteria, bacterial viruses, fungi, and protozoa. Emphasis will be placed upon the special features of these organisms which permit unique contributions to be made to our understanding of the nature of the genetic material and the fundamental mechanisms concerned in its mutation, replication, recombination, interaction with cytoplasmic components and metabolic functioning. Three hours of lecture or discussion per week.

B. The following graduate courses may be taken for undergraduate credit with the permission of the instructor.

BIO 401 *Cellular Biology.* Fall semester. 4 hrs.

A course designed to present current thinking and progress in problems concerning cell structure, function, and the relationship between the two. The approach is basically analytical, striving where possible to explain cellular phenomena

BIO 422 *Seminar on Molecular Biology.* Spring semester. 3 hrs.

A presentation and discussion of current literature on molecular biology. Topics to be included are the molecular organization of DNA and RNA and the molecular basis of: mutation, DNA replication, genetic recombination, transcription of genetic information and its transfer to the protein-synthesizing machinery of the cell, and genetic elements in the regulation of cellular metabolism. The discussion will be designed to make clear the essential simplicity of the conceptual approaches which have utilized biophysical and biochemical techniques in studying such problems, as well as revealing the current status of our knowledge. Three hours of discussion a week.

BIO 443 *Current Problems in Animal Behavior.* Each semester. 1 hr.

A weekly seminar devoted to reviews and discussion of investigations, methods, and literature in comparative behavior.

BIO 451 *Interarea Seminar.* Each semester. 1 hr.

Each semester, two of the staff combine their interests to develop a series of topics and review of the literature which touches on both fields of interest.

BIO 491 *Research.* Each semester. Credits to be arranged.

Original investigation undertaken with the supervision of one of the staff.

Departmental colloquim. Each semester.

A weekly series of talks and discussions by members of the staff, advanced graduate students, and visiting biologists, in which will be presented current research and thinking in various areas of biology.

Additional graduate courses will be offered beginning in 1965-66.

Chemistry

Professors Bonner (Chairman), Ramirez, Sujishi; *Associate Professors* Alexander, Kosower, Lauterbur; *Assistant Professors* Bernal, Boikess, Goldfarb, Kern, le Noble, Lepley, Schneider, Solo.

Admission to Graduate Study

For admission to graduate study in chemistry the following are required:

A. Baccalaureate degree in chemistry from an institution accredited by the American Chemical Society, or an equivalent course of study. The undergraduate background should include completion of five years of college work in chemistry, including one year each of work in general, quantitative, organic and physical chemistry. It should also include at least one year of college physics and two years of college mathematics, including differential and integral calculus.

B. A minimum grade-point average of 2.75 (B–) in all undergraduate course work, and 3.00 (B) in all courses in the sciences and in mathematics.

C. Acceptance by the Department of Chemistry and by the Graduate School.

In exceptional cases, a student not meeting the requirements (A) and (B) may be admitted on a provisional basis. Upon entrance, the student will be informed of the requirements he must satisfy to terminate his provisional standing.

Orientation Examination

Within the two-week period preceding opening of classes for the fall semester, a series of three orientation examinations in the fields of physical, inorganic and organic chemistry will be administered to all incoming graduate students. These examinations will be based upon final examinations given in the junior and senior years of the undergraduate program of the State University at Stony Brook. The purpose of the orientation examination is primarily to aid in the advising of incoming graduate students concerning their first-year programs.

Seminars

All graduate students will register for a chemistry seminar. In the course of his first year each student shall present a topic of his own selection.

All first year graduate students will attend a pre-research seminar in which the faculty members of the Department of Chemistry will present talks on their research programs. The objective of these seminars is to provide information which will allow the student to make an intelligent selection of a research problem.

In addition to the above, all graduate students are required to attend the Department's regularly scheduled general seminars. These seminars are presented by outstanding chemists invited from outside the University.

Research Advisor

In order to discover and develop ability to do independent and productive scientific research, it is desirable for the student to undertake a research program as soon as possible. Upon conclusion of the pre-research seminar series, each first-year student shall apply to a faculty member of his choice for acceptance as a research student, and shall then apply to the Chairman of the Department of Chemistry for final approval.

The research advisor becomes the academic advisor for the student, and his subsequent program of study must meet with the approval of the research advisor.

Faculty research programs currently in progress include synthetic and physicochemical studies of molecular inorganic hydrides, organophosphorus compounds, enzymatic systems, organic π-complexes, nonclassical organic ions, organic systems under high pressure; studies of nuclear reactions; cosmic-ray induced radioactivity and isotope geochemistry; nuclear magnetic resonance; electron paramagnetic resonance; direct quadrupole resonance; high resolution infrared and far infrared; flash photolysis in gaseous systems; and theoretical chemistry.

Courses of Study

Students will be advised concerning courses of study appropriate to their backgrounds. The objective of the course of study in

the first year is the development of breadth in chemistry, and a typical first-year program for a graduate teaching assistant is as follows:

FIRST SEMESTER

Advanced Organic Chemistry (CHE 401)	2
Advanced Inorganic Chemistry (CHE 411)	2
Advanced Physical Chemistry (CHE 421)	3
Seminar (CHE 431)	0
Elective	2

SECOND SEMESTER

Chemical Thermodynamics (CHE 424)	3
Chemical Kinetics (CHE 426)	2
Physical Organic and Inorganic Chemistry (CHE 404)	2
Research (CHE 499)	1
Seminar (CHE 432)	1

Qualification to Candidacy

The qualifications of each first year graduate student will be reviewed by the faculty of the Department of Chemistry in May, and the students will be either accepted or rejected for qualification to candidacy for a graduate degree.

Requirements for the M.S. Degree

A. Residence: one year minimum

B. Qualification to candidacy

C. Language: reading proficiency in German or Russian

D. Formal course requirement: successful completion of an approved course of study comprising at least 24 graduate credit hours

E. Thesis

F. Oral Defense of Thesis: Upon acceptance of an M.S. thesis by a reading committee, the student is admitted to oral defense of his thesis. Upon recommendation of the oral defense committee, the Chairman of the Department recommends acceptance or rejection of the thesis to the Dean of the Graduate School.

Requirements for the Ph.D. Degree

A. Residence: two years minimum

B. Qualification to candidacy

C. Language: reading proficiency in German, and in a second foreign language in which there exists a substantial body of chemical literature.

D. Formal Course Requirement: successful completion of an approved course of study.

E. Advancement to candidacy: In order to be advanced to candidacy for the Ph.D. degree the student must satisfy the language requirement, demonstrate satisfactory progress in research, and satisfy the cumulative examination requirement. The cumulative examination is intended to provide a means by which the student's depth of knowledge in a specialized area can be demonstrated. These examinations will be offered at eight stated dates each year in the three major areas of physical, inorganic and organic chemistry. For admission to candidacy, a student must pass six examinations in a major area within the first two years after qualification to candidacy. At least two of these must be passed in the first year following qualification.

F. Thesis

G. Oral Defense of Thesis: Upon acceptance of a Ph.D. thesis by a reading committee, the student is admitted to oral defense of his thesis. Upon recommendation of the oral defense committee, the Chairman of the Department recommends acceptance or rejection of the thesis to the Graduate School.

Courses

A. Advanced undergraduate courses

CHE 301, 302	Experimental Methods of Chemistry I and II
CHE 305	Intermediate Inorganic Chemistry
CHE 315	Intermediate Organic Chemistry
CHE 325	Intermediate Physical Chemistry

B. Graduate courses

CHE 401 *Advanced Organic Chemistry.* 2 hrs.

Useful and modern reactions used to construct organic molecules will be surveyed. These will include condensation reactions, benzyne chemistry, organophosphorus and organoboron chemistry, metal carbonyl reactions and acetylene chemistry.

CHE 404 *Physical Organic and Physical Inorganic Chemistry.* 2 hrs.

A concise and intensive survey of the mechanisms of chemical transformation, including Sn^1 and Sn^2 reactions, allylic and other rearrangements, Diels-Alder reaction, carbonyl addition reactions, substitution and electron-transfer reactions in coordination complexes, substitution on elements other than carbon, transition metal complexes.

CHE 411 *Advanced Inorganic Chemistry.* 2 hrs.

The thermodynamic and structural properties of inorganic systems of current interest will be discussed. These will include elementary and binary systems at high temperatures, simple and complex hydrides, and polynuclear and complex ions.

CHE 416 *Nuclear Chemistry.* 3 hrs.

Topics include the properties of radioactive substances and their use in the study of chemical problems; nuclear structure; a study of nuclear reactions; radioactive decay and growth; interactions of radiation with matter; detection and measurement of radiation, including a discussion of statistics; application of radioactivity to chemical problems such as kinetics, structure, and analysis; artificially produced elements; and chemical phenomena accompanying nuclear reactions.

CHE 421 *Advanced Physical Chemistry.* 3 hrs.

Elementary quantum and statistical mechanics will be applied to problems of chemical interest, including chemical bonding and molecular structure. The interpretation of ultraviolet-visible, infrared and radio-frequency spectroscopic data will be emphasized.

CHE 444 *Physical Organic Chemistry* (II). 2 hrs.

A detailed consideration of current topics which may include the following: solvolysis reactions (neighboring group effects, salt effects, allylic and homallylic compounds, solvent effects); isotope effects of reaction rates; charge-transfer complexes and spectra; aromatic, electrophilic, nucleophilic, and free-radical substitution; photochemistry; and free-radical reactions.

*CHE 445 *Intermediates in Organic Chemistry.* 2 hrs.

The most important intermediates in organic reactions (free-radicals, carbonium ions, carbanions, benzynes, carbenes, etc.) are discussed on the basis of evidence such as the products of reaction, kinetics, spectral observation, etc. Emphasis is on recent work not yet digested by the textbooks.

CHE 447 *Molecular Biochemistry.* 2 hrs.

The application of physical-organic chemistry to biochemical reactions, including a survey of intermediary metabalism and mechanistic analysis of such reactions as decarboxylations, hydration, hydrolysis, electron-transfer reactions, hydrogen-transfer reactions and reactions of phosphates.

CHE 449 *Theoretical Organic Chemistry.* 2 hrs.

The methods of chemical physics are applied to complex organic systems. Simplifying assumptions and empirical parameters for the linear combination of atomic orbital-molecular orbitals, self consistent field, free electron, and split-p-orbital treatments are considered. These methods are then used for spectral interpretation and correlation function determination. Reactivity indices, localization energies, free valence, bond order and polarizability are discussed.

*CHE 456 *Applications of Nuclear Chemistry.* 2 hrs.

The application of radioactive and stable nuclides to selected fields of chemical research, including chemical kinetics, structural chemistry, self-diffusion, chemical analysis, hot-atom chemistry, and geochemistry. Strong emphasis will be placed upon student participation in the presentation of specialized topics.

*CHE 461 *Topics in Chemical Physics.* 2 hrs.

Advanced topics in quantum mechanics will be treated including applications of group theory to chemical problems, perturbation theory, collision theory and certain aspects of the theory of spectroscopy of molecules.

*CHE 462 *Introduction to Statistical Mechanics.* 2 hrs.

Techniques will be discussed which permit the calculation of macroscopic properties for a variety of chemical systems given the detailed nature of the microscopic substructure of the system. The above techniques, which lead to results paralleling those of thermodynamics, will be applied to ideal and real gases, crystals, and liquids. In addition some kinetic properties of systems will be examined.

CHE 464 *Molecular Spectroscopy.* 2 hrs.

A detailed description for the theory and practice of rotational, vibrational and electronic absorption spectroscopy. Topics to be covered will include energy levels, force fields, and selection rules for polyatomic molecules. Emphasis will be on the application of spectroscopic data to molecular structure and other problems of chemical interest.

CHE 465 *Magnetic Resonance.* 2 hrs.

A study of the theory of magnetic and electrostatic interactions among nuclei and electrons, and of the experimental techniques used to observe them. Applications of magnetic resonance spectroscopy to a number of topics of chemical interest, including rate processes, the electronic structures, conformations, and motions of molecules, and the structures and electronic properties of solids will be discussed.

* Not offered during academic year 1963-64.

Physics

Professors Balazs, Eisenbud, Feingold, Fox, Muether, Pond (Chairman); *Associate Professors* Lambe, Mould, Raz, Silsbee, Swartz; *Assistant Professors* deZafra, Kahn, Kao, Lee-Franzini.

Admission to Graduate Study

For admission to graduate study in physics, the following are required:

A. Baccalaureate degree in physics from an accredited institution, with departmental course requirements in physics equivalent to those at this institution (including courses at the junior and senior level in Electromagnetic Theory, Mechanics, Methods of Theoretical Physics, Quantum Mechanics and Modern Physics, Advanced Laboratory).

B. A minimum grade average of B in all undergraduate course work, and of B in physics, mathematics, and chemistry.

C. Acceptance by the Department of Physics and by the Graduate School.

In special cases, a student not meetings requirements (A) and (B) may be admitted on a provisional basis. Upon entrance, the student will be informed of the requirements he must satisfy for the termination of the provisional status.

First-Year Program

The student's program for the first year of graduate study will be determined on the basis of past records and an interview or examination, given at the beginning of the first semester.

Qualifying Examination

An examination will be given to each graduate student in February of his first year, to determine whether he may continue his graduate studies.

Requirements for the M.A. Degree

A. Residence: one year.

B. Advancement to candidacy.

C. Courses: The student must complete a program of courses which is approved by his faculty advisor and which include PHY 401 (Analytical Mechanics), PHY 402 (Electrodynamics) and PHY 411 (Quantum Mechanics I).

D. Language requirement: Before the candidate receives permission to take the final examination for the M.A. degree he must demonstrate proficiency in reading scientific material in one of the following foreign languages: German, French, Russian.

E. Final examination: A final examination will be given, covering both material studied in the course work and information which the student is expected to attain through supplementary reading and attendance at colloquia and seminars.

The Ph.D. Program

While there are no formal course requirements for advancement to candidacy for the Ph.D., it is expected that most students will be advised to take courses in preparation for the preliminary examination. The following constitutes a sample program for a student who is admitted with no special conditions to satisfy, and who holds a teaching assistantship:

First Semester
Analytical Mechanics
Quantum Mechanics I
Statistical Mechanics

Second Semester
Electrodynamics
Quantum Mechanics II
Nuclear Physics

Third Semester
Theoretical Nuclear Physics
Solid State Physics
Advanced Quantum Mechanics

Fourth Semester
Solid State Theory
Electives

Requirements for the Ph.D. Degree

A. Preliminary examination: The preliminary examination will be given in two parts. Part A will be a written examination, and will cover the following topics: Analytical Mechanics, Electro-

dynamics, Statistical Mechanics, Methods of Theoretical Physics. Part B will be partly written and partly oral, and will cover Quantum Mechanics, Nuclear Physics, Solid State Physics. Part B will also include questions on recent developments, not necessarily discussed in the courses, which the student is expected to learn through independent reading and attendance at colloquia and seminars. A student who is admitted to graduate study with no conditions will ordinarily take Part A in September of his second year and Part B the following September.

B. Language Examinations: The student is expected to have a reading knowledge of two of the following languages: German, Russian, French. Proficiency in one of these languages must be demonstrated before Part A of the preliminary examination is taken, and in the second language before Part B.

C. Advancement to Candidacy: The department's recommendation with respect to advancement to candidacy will be based primarily on the satisfactory completion of requirements A and B.

D. Research and Thesis: The candidate's thesis committee is appointed by the Graduate School upon recommendation of the department chairman. The chairman of the committee is the candidate's research and thesis advisor. (Although this formal arrangement begins after admission to candidacy, the student is expected to have an informal association with a research group at an earlier stage.)

E. Thesis Examination: An examining committee will read the thesis and give the candidate an oral examination on the research topic and related areas. Upon recommendation of the committee, the department chairman recommends acceptance or rejection of the thesis to the Graduate School.

Courses

A. Advanced undergraduate courses

PHY 341, 342—Quantum Mechanics and Modern Physics

PHY 343, 344—Methods of Mathematical Physics I and II

PHY 345, 346—Senior Laboratory

B. Graduate courses to be offered in 1963-64:

PHY 401 *Analytical Mechanics.* 3 hrs.

Dynamics of particles and rigid bodies, Lagrange's and Hamilton's equations, variational principles, cononical formulation, Hamilton-Jacobi equation.

PHY 402 *Electrodynamics.* 3 hrs.

Maxwell's equations, scalar and vector potential theory, boundary value problems, electromagnetic waves and radiation.

PHY 411 *Quantum Mechanics I.* 3 hrs.

Review of basic principles of quantum theory with applications to atomic, molecular, nuclear, and solid state physics; stationary state and time dependent perturbation theory, elementary collision problems.

PHY 412 *Quantum Mechanics II.* 3 hrs.

Formal structure of quantum theory, collision problems and formal scattering theory, elementary quantization of the radiation field, introduction to Dirac electron theory.

PHY 415 *Statistical Mechanics.* 3 hrs.

Boltzmann statistics, H theorem and entropy, quantum statistics, microscopic approach to thermodynamics

PHY 420 *Nuclear Physics.* 3 hrs.

Basic properties of nuclei, nuclear forces, radioactivity, fission, electromagnetic properties; experimental techniques, accelerators and nuclear detectors.

PHY 440 *Special Research Projects.* Each semester. Variable and repetitive credit.

Research under the direction of a faculty member. Not open to Ph.D. candidates who have passed the preliminary examination.

PHY 442 *Special Study.* Each semester Variable and repetitive credit reading course in selected topics.

PHY 445 *Solid State Physics.* 3 hrs.

Crystal structure, symmetry and space groups, ionic crystals, band theory of metals and semiconductors, transport phenomena, imperfections, magnetic and dielectric phenomena, low-temperature properties of solids.

PHY 446 *Solid State Theory.* 3 hrs.

Transport properties of solids, including interactions of electrons with various imperfections; galvomagnetic and thermoelectric effects; optical, spectroscopic and photoelectric properties; dielectric and magnetic properties.

PHY 451 *Theoretical Nuclear Physics.* 3 hrs.

The two-body problem, theory of nuclear forces and properties of nuclear matter, nuclear models, formal theory of nuclear reaction.

PHY 455 *Advanced Quantum Mechanics.* 3 hrs.

Symmetries and invariance principles, relativistic electron theory, introduction to field theory.

PHY 460 *High Energy Physics.* 3 hrs.

Experimental techniques, cascade theory, meson interactions, fundamental particle systematics, weak and strong interactions, ultra-high energy phenomena.

PHY 470 *Relativity.* 3 hrs.

Special and general theories of relativity; cosmology; unified field theories.

PHY 499 *Thesis Research.* Both semesters. Variable and repetitive credit.

Independent research for Ph.D. degree. Open only to candidates for the Ph.D. who have passed preliminary examination.

C. Graduate courses to be offered beginning in 1964-65

PHY 465, 466 *Quantum Field Theory I, II.* 3 hrs. each term.

Field quantization; scalar and pseudoscalar meson field; electromagnetic field, Dirac field, interacting fields; Feynman diagrams; charge and mass renormalization; dispersion relations.

PHY 481 *Special Topics in Theoretical Physics.* Both semesters, 3 hrs. per semester, repetitive credit.

Subject matter varies from semester to semester, depending on interests of students and staff. Advanced topics such as group theory and applications, modern topics in field theory.

PHY 483 *Special Topics in Nuclear Physics.* Both semesters, 3 hrs. per semester, repetitive credit.

Subject matter varies from semester to semester, depending on interests of students and staff. Current advanced topics in nuclear physics such as theory of angular correlations, photonuclear reactions, 3-decay theory, collective vibrations.

PHY 485 *Special Topics in Solid State Physics.* Both semesters, 3 hrs. per semester, repetitive credit.

Subject matter varies from semester to semester, depending on interests of students and staff. Advanced and special topics of current interest such as theory of super-conductivity, resonance phenomena and applications, plasma dynamics; advanced treatment of topics discussed in Physics 610, 611.

College of Engineering

Engineering Analysis

Professors Gerst (Chairman), Finerman, Zemanian; *Assistant Professor* Dicker.

Members of the Department of Electrical Sciences participating in the Engineering Analysis Graduate Program: *Professor* Chang (Chairman); *Assistant Professor* Dollard.

Admission to Graduate Study

For admission to graduate study in Engineering Analysis, the following are required:

A. A Baccalaureate degree, with the major subject being in either mathematics, engineering, science or a related area, from an accredited college or university.

B. A minimum grade average of at least "B" in all mathematics, engineering, and science courses.

C. Acceptance by the Department of Engineering Analysis and by the Graduate School.

In special cases, a student not meeting requirements A or B may be admitted on a provisional basis. Upon entrance, the student will be informed of the requirements he must satisfy to terminate his provisional standing.

Requirements for the M.S. Degree

A. Residence: one year.

B. Formal course requirements: At least 30 credit-hours must be earned for the Master's degree, of which 27 credit-hours is to be for graduate course work and 3 credit-hours for the Master's thesis. In addition, the grades in courses totaling at least 21 credit-hours must be "B" or better, and the average grade for all courses taken during the Master's program must also be "B" or better. The fol-

lowing course is a required one for all students in the Master's program: Analysis of Linear Systems I and II.

The student, with the advice of the Departmental Graduate Administrative Committee, shall prepare a program of studies. This program will be reviewed and must be approved by the Departmental Graduate Administrative Committee before the student is admitted to candidacy.

The following is a sample program of course work leading to the Master's degree for a student who holds a graduate assistantship:

Semester I		Semester II	
Analysis of Linear Systems I	3	Analysis of Linear Systems II	3
Principles of Engineering Analysis I	3	Principles of Engineering Analysis II	3
Random Processes in Engineering Systems I	3	Random Processes in Engineering System II	3

Semester III

Theory of Approximation	3
Complex Variable Theory with Applications	3
Distribution Theory and its Applications	3

A student who does not hold a graduate assistantship will ordinarily take one additional three-credit course per semester.

C. Master's thesis: The composition of a significant essay on some topic in engineering analysis is a requirement for the Master's degree in this department. Ordinarily, the student registers for the Master's thesis, which is a three-credit-hour subject, during the last two semesters of residence. This thesis is essentially an expository discussion of a particular topic. It shall demonstrate a mastery of the subject and shall contain a thorough literature search for the purpose of summarizing the recent contributions and ascertaining the outstanding problems. The student is encouraged to attempt original work on these problems.

To this end, the student shall determine a faculty member who approves of his thesis topic and agrees to act as his Master's thesis advisor. The completed thesis must receive the approval of the thesis advisor and of the Departmental Graduate Administrative Committee in order for this requirement to be satisfied.

D. Admission to candidacy: The status of Candidate for the Master's degree is conferred upon the student by the Dean of the Graduate School upon the recommendation of the faculty of the Department of Engineering Analysis. The student is eligible for candidacy only after he fulfills one semester's residence or the equivalent, and has his program of courses and thesis topic approved by the Departmental Graduate Administrative Committee. The faculty will base its recommendation upon the records submitted at the time of admission, the student's performance in his course work, and the opinions of those faculty members who are familiar with the student's abilities.

E. Final departmental recommendation: Upon the fulfillment of the above requirements the faculty of the Department of Engineering Analysis will review the student's performance and record. They then will either recommend the Degree of Master of Science in Engineering be conferred or will stipulate further requirements that the student must fulfill.

Requirements for the Ph.D. Degree

A. Residence: two years.

B. Languages: A reading ability in two foreign languages of technical literature relevant to the student's research interests is required. Acceptable foreign languages are French, German, and Russian. The student's choice of languages, which may include other foreign languages, must be approved by his Graduate Advisory Committee. This language requirement must be satisfied before the student is admitted to the candidacy to the Doctor of Philosophy degree.

C. Course requirements: There are no formal course requirements for the Ph.D. degree. However, it is anticipated that two full academic years of course work beyond the Bachelor's degree will normally be required as preparation for the preliminary examinations.

D. Qualifying examination: The department will satisfy itself by a written qualifying examination that students who signify an intent to undertake study for the Ph.D. degree are qualified to do so. This examination shall be taken before the third semester of residency is completed. A postponement beyond this time can be obtained only with the approval of the Departmental Graduate Administrative Committee.

E. Plan of work: Upon successful completion of the qualifying examination, a plan of work is to be prepared by the student. The Departmental Graduate Administrative Committee will aid the student in the preparation of this plan, which will include the proposed course work, a thesis advisor, and a tentative thesis topic. For this purpose, the student shall propose a faculty member who approves of his projected research area and agrees to act as his thesis advisor.

F. Preliminary examination: Upon completion of the course work, a comprehensive oral examination, which may be supplemented by a written examination, will be given to the student. The student may not register for the doctoral thesis until he passes this examination.

G. Admission to candidacy: The status of candidate for the Doctor of Philosophy degree is conferred upon the student by the Dean of the Graduate School upon the recommendation of the Graduate Advisory Committee. The student is eligible for candidacy only after he satisfies the language requirements and passes the preliminary examination.

H. Doctoral thesis: The most important requirement for the Doctor of Philosophy degree is the preparation of a doctoral thesis, which is an original scholarly investigation. The thesis shall represent a significant contribution to the scientific literature. Its minimum quality shall be compatible with the publication standards of appropriate reputable scholarly journals.

I. Defense of the thesis: The student will defend his thesis before an examining committee. On the basis of the recommendations of this committee, the Chairman of the Department will recommend acceptance or rejection of the thesis to the Graduate School.

All departmental requirements for the Doctorate will have been satisfied when the student achieves the status of Candidate for the Doctor of Philosophy Degree and then successfully defends his thesis.

Graduate Course Offerings

Each course listed below carries 3 hours of credit.

ESA 401 *Analysis of Linear Systems I.*

Propagation problems in discrete systems, integral transform techniques, system functions, convolution, applications of complex variables, stability.

ESA 402 *Analysis of Linear Systems II.*

Propagation problems in continuous systems, solution of partial differential equations by transform techniques, asymptotic relations, iterative structures, sampled-data systems, z-transform, systems with memory.

ESA 403 *Principles of Engineering Analysis I.*

Equilibrium and characteristic value problems in discrete engineering systems. Development and application of pertinent material from the following subjects: matrix calculus, linear vector spaces, transformation theory and spectral decomposition, extremum principles, numerical methods.

ESA 404 *Principles of Engineering Analysis II.*

Equilibrium and characteristic-value problems in continuous engineering systems. Development and application of pertinent techniques from the following subjects: Sturm-Liouville theory, orthogonal functions, special functions, variational principles, integral equations, Green's function, conformal mapping, theory of characteristics, analytical and numerical methods of solution.

ESA 405, 406 *Random Processes in Engineering Systems I and II.*

A study of various engineering systems and sub-systems which involve random phenomena as an integral part of system design. Concepts and techniques used in treating such systems are developed. Utilization is made of relevant material from the following subjects: random variables, probability distributions, mean-values, variance, stochastic processes, characteristics functions, spectral density and autocorrelation, laws of large numbers, central limit theorem, recurrent events and Markov chains, statistical inference and

decision procedures. Applications are made to noise theory, quality control, queueing theory, design of experiments, and Monte Carlo procedures, with the objective of obtaining statistically optimum system design.

ESA 411 *Complex Variable Theory with Applications.*

A study of those concepts and techniques in complex variable theory which are of interest for their engineering applications. Pertinent material is selected from the following topics: complex algebra, analytic functions, harmonic functions, integration in the complex plane, Taylor and Laurent expansions, singularities, calculus of residues, entire and meromorphic functions, conformal mapping. Application is made to problems in heat conduction, potential theory and fluid mechanics.

ESA 415 *Non-linear Systems.*

Basic non-linear differential equation theory. Analytical, graphical and approximation techniques for studying the behavior of non-linear engineering systems. Application of phase-plane and describing function techniques.

ESA 421 *Advanced Operational Methods in Engineering Systems.*

An advanced course in the application of operator techniques to the analysis of engineering systems. Topics covered include: the general integral transform, Hilbert, Hankel and Mellin Transforms, finite transforms, Wiener-Hopf technique, generating functions, asymptotics, Mikusinski operational calculus.

ESA 422 *Advanced Boundary Value Problems in Engineering Systems.*

An advanced course in the treatment of engineering systems which give rise to boundary-value problems. Applications of the following are made: general operator theory and functional analysis, Hilbert space, singular integral equations, theory of distributions.

ESA 423 *Distribution Theory and its Applications.*

Spaces of testing functions and distributions. The calculus of distributions. Distributions as derivatives of continuous functions; their direct product, convolution, and Fourier and Laplace transforms. The relationship between distribution theory and other theories of generalized functions, such as Lighthill's and Sauer's. The algebra of convolution and its relationship to Mikusinski's operational calculus. Applications to the analysis of linear systems. The Schmieden-Laugwitz extension to calculus. The use of distribution theory in engineering analysis is emphasized throughout.

ESA 424 *Theory of Approximation.*

A survey of various engineering situations which present special problems in approximation theory, followed by an extensive development of methods for treating these problems. Topics covered include: smoothing of data, least-squares methods, Chebyshev approximation, approximation by rational functions, orthogonal functions, Hilbert Space methods, general aspects of approximation in normed linear spaces.

ESA 425 *Approximate Methods in Engineering Boundary Value Problems.*

A survey of boundary value problems arising in engineering for which analytical solutions are either unavailable or of little practical value, followed by an intensive study of various techniques for the approximate solution of these problems. Topics covered include numerical solutions by means of finite differences; approximate analytical solutions such as Galerkin's method, collocation, Ritz method, and the method of least squares. Applications are drawn from the areas of fluid mechanics, elasticity, heat transfer, and potential theory.

ESA 431 *Applied Group Theory.*

The object of this course is to acquaint the student with the basic concepts of finite groups and their application to atomic spectra, molecular spectra and theory of solids.

ESA 451 *Feedback Control Systems I.*

Analysis and synthesis of automatic control systems, Nyquist and Bode plots, root locus method, multiple loop systems, synthesis through pole-zero configurations, compensating networks.

ESA 452 *Feedback Control Systems II.*

Statistical design theory, minimization of integral-square error, sampled data systems, adaptive control systems.

ESA 453 *Sampled-Data Engineering Systems.*

Development of the concepts and techniques pertaining to the analysis and synthesis of discrete systems and to related problems. Z-transform methods. Sampling continuous data. Smoothing sampled data. Sampled-data feedback systems. Application of digital methods to continuous systems. Digital filters. Response to random inputs. Statistically optimum discrete systems and adaptive systems.

ESA 454 *Information Theory.*

A systematic development of the concepts and facts of information theory. Definition of a measure of information and study of its properties. Optimum coding and the noiseless coding theorem. Transmission in the presence of random disturbances. Theorem on capacity and reliable transmission. Error correcting codes. The binary symmetric channel. Applications to communication and thermodynamics.

ESA 461 *Vibrations.*

Principal modes and natural frequencies of discrete and continuous systems. Forced vibrations, dissipative continua. Stability analysis. Introduction to nonlinear vibrations.

ESA 463 *Hydrodynamics.*

The mathematical theory of inviscid fluid motions. Irrotational motion, flow nets, conformal mapping, Schwarz-Christoffel transformation. Applications to subterranean flow and surface waves, aerodynamics, hydrodynamic stability.

ESA 481 *Topics of Engineering Analysis.*

Selected topics from various fields of engineering which require specialized development of subjects in the fields of analysis and algebra. Examples are network synthesis and positive real functions, single side-band transmission and Hilbert transforms, error-correcting codes and Galois fields.

ESA 491 *Seminar in Engineering Analysis.*

Supervised reading and discussion of current journal publications in engineering analysis.

In addition to the courses listed above, it is expected that the following graduate courses will be offered in the near future:

Advanced Mechanics
Finite-State Engineering Systems
Graph-Theoretic Methods in Engineering Analysis
Methods of Operations Research
Theory of Elasticity
Variational Methods in Engineering

Thermal Sciences

Professors Bradfield (Chairman), Irvine (Dean, College of Engineering); *Associate Professors* Cess, Snyder; *Assistant Professor* O'Brien.

Members of the Department of Material Sciences participating in the Thermal Sciences Graduate Program: *Professor* Levine (Chairman); *Associate Professor* Jach; *Assistant Professor* Rosenberg.

Admission to Graduate Study

For admission to graduate study in Thermal Sciences, the following are required:

A. A B.S. degree in Engineering, or in a closely related area, from an accredited college or university.

B. A minimum grade average of B in all courses in engineering, natural sciences, and mathematics.

C. Acceptance by the department and by the Graduate School.

In special cases, a student not meeting requirements A and B may be admitted on a provisional basis. Upon entrance, the student will be informed of the requirements he must satisfy to terminate his provisional standing.

Requirements for the M.S. Degree

A. Residence: One academic year on a full-time basis.

B. Formal course requirements: 30 credit hours in which a grade of A or B has been achieved; not more than 6 of these credits will be granted for the thesis.

C. Qualification to candidacy (see below).

D. Thesis

E. Oral defense of thesis: Upon acceptance of the thesis by a reading committee, the student is admitted to oral defense of his thesis. Upon recommendation of the oral defense committee, the Chairman of the Department recommends acceptance or rejection of the thesis to the Graduate School.

Qualification to Candidacy

The qualification of each graduate student shall be reviewed by the faculty of the Department of Thermal Sciences after one semester's residence. This review is for the purpose of recommending the graduate student for candidacy. Decisions will be based upon records submitted at the time of admission, performance in formal course work, and the opinion of the student's research advisor.

Requirements for the Ph.D. Degree

A. Residence: two years

B. Languages: either German or Russian, and one additional language approved by the department.

C. Qualifying examination: The department will satisfy itself by written qualifying examination that students who signify intent to undertake study for the Ph.D. degree are qualified to do so. This examination shall precede the comprehensive preliminary examination by a minimum of approximately two semesters. Students must make arrangements with the department to take the examination.

D. Preliminary examination: Upon completion of course work, a comprehensive written preliminary examination will be given. A comprehensive oral preliminary examination will follow the successful completion of the written examination.

E. Advancement to candidacy: The department will recommend to Graduate School that the student be advanced to candidacy after his successful completion of the language and preliminary examinations.

F. Research and thesis: By the end of the second semester of residence, the Department Chairman, after consultation with the student, shall request the appointment by the Graduate School of a Graduate Advisory Committee. The student will present for approval to this Committee a plan for future course work, the name of a proposed thesis advisor, and a tentative thesis topic. The research and the writing of the thesis will be carried out under the direction of the thesis advisor.

Oral defense of thesis: The student will defend his thesis before an examining committee. On the basis of the recommendation of this committee, the Chairman of the Department will recommend acceptance or rejection of the thesis to the Graduate School.

Sample Programs

The following is a sample program, leading to the M.S. degree, for a full-time student who is well prepared on admission to graduate study:

Semester I		Semester II	
Advanced Heat Transfer I	3	Advanced Heat Transfer II	3
Advanced Fluid Mechanics I*	3	Advanced Fluid Mechanics II*	3
Advanced Engineering Analysis I	3	Advanced Engineering Analysis II	3
Theoretical Physics I	3	Theoretical Physics II	3
		Thesis (Summer)	6

* More specialized courses will be substituted for students intending to continue through to the doctoral program.

The following sample program, for a full-time student concentrating in Fluid Mechanics, leads from the Master's degree to the Doctorate:

Semester III		Semester IV	
Perfect Fluid Theory	3	Magnetohydrodynamics	3
Homogeneous Turbulence	3	Seminar in Thermal Sciences	3
Elective in Physics	3	Physical Gas Dynamics*	3
Elective in Mathematics	3	Elective in Mathematics	3
		Comprehensive examinations for candidacy.	
		Dissertation.	
		Final oral defense of dissertation.	

* Equivalent courses at predoctoral level in the Mathematics or Physics Department may be substituted, with consent of the student's committee (e.g., quantum mechanics, statistical mechanics, field theory, partial differential equations, calculus of variations).

Other Participating Departments

In addition to the faculty of the Department of Thermal Sciences, faculty members in other departments of the College of Engineering will offer graduate level courses in related areas. These

will include courses in energy conversion, molecular theory of fluids, advanced engineering analysis and computer logic.

Courses

A. Advanced undergraduate courses

EST 371 Compressible Fluid Mechanics

EST 372 Boundary Layer Theory

EST 375 Viscous Fluids

EST 401, 402 *Advanced Heal Transfer.* 3 hrs. each semester.

Thermal boundary layers in forced and free convection, heat transfer in internal flows, two-phase boundary layer flows. Thermal radiation, formulation of radiation problems in terms of integral equations, radiant transfer with absorbing-emitting gases.

EST 411, 412 *Advanced Fluid Mechanics I and II.* 3 hrs. each semester.

Lagrangian and Eulerian frames, Rayleigh transport theorem and kinematic surface conditions, elementary kinetic theory, dynamical equations of motion, energy and momentum transfer, classes of constitutive relations. Fluid statics, including self-gravitation stability of floating bodies, surface tension effects and statics of the earth's atmosphere. Significant features of fluid dynamics of incompressible and barotropic perfect fluids and of the compressible perfect gas. Characteristic surfaces and shock waves. Internal and surface waves. Constitutive equations of viscous fluids. Some exact solutions of the Navier-Stokes equations. The nature of laminar instabilities.

EST 413 *Mechanics of non-Newtonian Fluids.* 3 hrs.

Classes of stress-strain relations. Mathematical techniques useful in formulating non-linear theories. Experimental information. Thixotropy and dilitancy. Flow of suspensions. Relationship of flow properties to molecular structures.

EST 414 *Homogeneous Turbulence.* 3 hrs.

Probability functions and generalized Fourier transforms. Kinematics. Invariance theory. Isotropic turbulence. Statistical theories. Local isotropy. Scalar transport.

EST 415 *Compressible Fluid Mechanics.* 3 hrs.

The general conservation equations of gas dynamics from a differential and integral point of view, hyperbolic compressible flow equations, unsteady one-dimensional flows, the non-linear problem of shock wave formation, isentropic plane flow, small perturbation theory, method of characteristics, hodograph method.

EST 416 *Viscous Fluids.* 3 hrs.

Constitutive equation of a viscous fluid. The Stokesian fluid in simple shear Navier-Stokes equation. Exact solutions. Low Reynolds number behavior, lubrication theory, flow through porous media. Asymptotic behavior at large Reynolds numbers, boundary layers, wakes and jets. Instability of laminar flows.

EST 417 *Perfect Fluid Theory.* 3 hrs.

Equations of motion. Potential theory. Two-dimensional motion. Axially symmetric flows. Stratified and rotating fluids. Finite and infinitesimal waves. Motions of rigid bodies in a perfect fluid.

EST 421 *Rarefied Gas Dynamics.* 3 hrs.

Basic concepts from statistical thermodynamics and the theory of non-uniform gases applied to the flow of rarefied gases.

EST 422 *Magnetohydrodynamics.* 3 hrs.

General concept of ionized gases, the Maxwell equations, electrodynamics of moving media, electromagnetic boundary conditions, the conservation equations derived from the Boltzmann equation, generalized Ohm's law, plasma oscillations and plasma wave phenomena, selected problems illustrating the physical features of plasma dynamics and magnetohydrodynamics.

EST 423 *Statistical Fluid Mechanics.* 3 hrs.

Statistical mechanical concepts, phase space, ensembles, distribution functions, relationship between microscopic and macroscopic properties of a continuum, the Boltzmann integrodifferential equation, approximate solutions to the Boltzmann equation including derivation of the macroscopic conservation equations, relationships between transport properties and molecular interaction models.

EST 424 *Boundary Layer Theory.* 3 hrs.

Navier-Stokes equations and their subsequent reduction to the boundary layer equations. General properties of the boundary layer equations, conditions for similarity, exact solutions, approximate methods, compressible boundary layers. Introduction to the fundamentals of turbulent flow, mixing length theories and their application to turbulent boundary layers.

EST 425 *Physical Gas Dynamics.* 3 hrs.

Study of thermomechanical flow processes resulting in dissociation, ionization, and recombination.

EST 426 *Shear-Flow Turbulence.* 3 hrs.

The fundamental equations of turbulent shear flow, boundary conditions, analytical and experimental results on boundary layer, jets, wakes, etc. Scalar transport in shear flows. Current problems in turbulent shear flows.

EST 427 *Theories of Transition.* 3 hrs.

Classical laminar stability under infinitesimal perturbations. Finite instabilities. Squires' theorem. Relevance to transition to turbulence. Experimental information on physics of transition. Turbulent spot model. Three dimensional effects. Current research.

EST 431 *Advanced Thermostatics.* 3 hrs.

Review of foundations of classical thermostatics: chemical equilibrium, phase and other aspects of multicompo-

nents systems equilibrium. Advanced formulations of the first and second laws, the Caratheodory formulations; stability of thermostatic systems; thermostatics in fields; surface and interfacial systems; higher-order phase transitions.

EST 432 *Thermodynamics of Irreversible Processes.* 3 hrs.
Thermodynamics of irreversible coupled flows; fluxes and forces; phenomenological relations; the principle of minimum entropy production; general analysis of diffusion phenomena; Knudsen's flow; electronic phenomena in solids, vacua, and plasmas; surface phenomena.

EST 444 *Aerothermochemistry.* 3 hrs.
A generalized treatment of combustion thermodynamics including a systematic derivation of thermodynamic equations, Bridgman tables, criteria for thermodynamic equilibrium, computation of equilibrium composition and adiabatic flame temperature. Introduction to classical chemical kinetics. Conservation equations for a reacting system, detonation and deflagration, theories of flame propagation, dynamics of a dissociating gas, flame stabilization.

EST 451 *Advanced Experimental Techniques.* 3 hrs.
Measure of information. Basic properties of instruments. Attainment of required experimental environment. Mechanical, electrical, and optical techniques.

EST 452 *Measurements System Design.* 3 hrs.
Design of research instrumentation in the context of the research problem. Selection of appropriate transducers for response to a given phenomenon and design of appropriate intermediate and readout components. Specific problems may be selected, depending upon the students' interest.

EST 496 *Special Problems in Thermal Sciences.* 3 hrs.
Conducted jointly by graduate students and one or more members of the faculty.

EST 499 *Research* (variable and repetitive credit)

STATE UNIVERSITY OF NEW YORK

Central Administrative Office: Albany 1, N. Y.

UNIVERSITY CENTERS

State University at Albany
State University at Buffalo
State University at Stony Brook

MEDICAL CENTERS

Downstate Medical Center at Brooklyn (New York City)
Upstate Medical Center at Syracuse

GRADUATE SCHOOL

Graduate School of Public Affairs at Albany

COLLEGES

College at Brockport
College at Buffalo
College at Cortland
College at Fredonia
College at Geneseo
College at New Paltz
College at Oneonta
College at Oswego
College at Plattsburgh
College at Potsdam
Harpur College at Binghamton
College of Forestry at Syracuse University
Maritime College at Fort Schuyler (New York City)
College of Ceramics at Alfred University
College of Agriculture at Cornell University
College of Home Economics at Cornell University
School of Industrial and Labor Relations at Cornell University
Veterinary College at Cornell University

TWO-YEAR COLLEGES

Agricultural and Technical Institutes at:

Alfred
Canton
Cobleskill
Delhi
Farmingdale
Morrisville

COMMUNITY COLLEGES

(Locally-sponsored two-year colleges under the program of State University)

Adirondack Community College at Hudson Falls
Auburn Community College at Auburn
Bronx Community College at New York City
Broome Technical Community College at Binghamton
Corning Community College at Corning
Dutchess Community College at Poughkeepsie
Erie County Technical Institute at Buffalo
Fashion Institute of Technology at New York City
Fulton-Montgomery Community College
Hudson Valley Community College at Troy
Jamestown Community College at Jamestown
Jefferson Community College at Watertown
Mohawk Valley Community College at Utica
Monroe Community College at Rochester
Nassau Community College at Garden City
New York City Community College of Applied Arts and Sciences at Brooklyn
Niagara County Community College at Niagara Falls
Onondaga Community College at Syracuse
Orange County Community College at Middletown
Queensborough Community College at New York City
Rockland Community College at Suffern
Staten Island Community College at New York City
Suffolk County Community College at Selden
Sullivan County Community College at South Fallsburg
Ulster County Community College at Kingston
Westchester Community College at Valhalla