

Electrochemical mass transfer in porous electrodes.



Dispersion of bacteria in suspension.



Damage to red blood cells caused by shear flow in artificial organs.



Filtration of emulsified oil by fibrous media.

For More Information Write to Prof. C. Judson King Department of Chemical Engineering University of California Berkeley, California 94720



Growth of single bubbles in a fluidized bed.

A SMALL PART OF THE CHEMICAL ENGINEERING SCENE AT BERKELEY



UNIVERSITY OF CALIFORNIA, SANTA BARBARA

The Department of Chemical and Nuclear Engineering offers a full program of graduate courses and research projects leading to hte M.S. and Ph.D. degrees in chemical engineering. Nine full-time faculty members direct research over a wide variety of chemical engineering and related nuclear engineering problems. Modern, well-equipped research laboratories and computer facilities (IBM 360/75) back up all research programs.

FACULTY . . . John E. Myers, Ph.D., Univ. of Michigan 1952. Professor of chemical engineering and chairman of Department. Research program: Two phase flow in porous media, mechanisms of boiling heat transfer.

Henri J. Fenech, Sc.D., Massachusetts Institute of Technology 1959. Professor of nuclear engineering. Research program: Reactor engineering and reactor analysis, heat transfer.

Owen T. Hanna, Ph.D., Purdue Univ. 1961. Associate professor of chemical engineering. Research program: Applications of mathematics in chemical engineering.

A. Edward Profio, Ph.D., Massachusetts Institute of Technology 1963. Associate Professor of Nuclear Engineering. Research program: Reactor experimental physics, neutron shielding, nuclear interaction with matter.

Robert G. Rinker, Ph.D., California Institute of Technology 1959. Associate professor of chemical engineering. Research program: Kinetics and reactor design, energy conversion, air pollution control.

Duncan A. Mellichamp, Ph.D., Purdue Univ. 1964. Assistant professor of chemical engineering. Research program: Dynamics of chemical processes, hybrid computer applications to adaptive and predictive control problems.

Paul G. Mikolaj, Ph.D., California Institute of Technology 1965. Assistant professor of chemical engineering. Research program: Thermodynamics and phase equilibria, structure of liquids and dense gases, oil pollution control. G. Robert Odette, Ph.D., Massachusetts Institute of Technology 1970. Assistant professor of nuclear engineering. Research program: Radiation effects on properties of materials.

Orville C. Sandall, Ph.D., Univ. of California, Berkeley 1966. Assistant professor of chemical engineering. Research program: Non-Newtonian heat transfer, interphase mass transfer, fluid mechanics of film flow.

CAMPUS . . . Santa Barbara is located on the Pacific coast one hundred miles north of Los Angeles. The campus occupies a 630-acre scenic promontory with the Santa Ynez mountains immediately behind. Fifteen thousand students are enrolled in programs in diverse fields of engineering, science, humanities and the arts. Attractive housing of all kinds is available within walking distance of the campus.

FINANCIAL ASSISTANCE AND ADMISSION PROCED-URES... Teaching assistantships are available to qualified students; the stipend begins at \$3,402 for the academic year with merit increases as progress is made towards a degree. A number of University Fellowships, Research Assistantships and various Traineeships are also available for qualified students. Information concerning departmental procedures can be obtained by writing Professor J. E. Myers, Department of Chemical and Nuclear Engineering, University of California, Santa Barbara 93106. Application forms for admission and financial assistance should be requested from the Dean of the Graduate Division, University of California, Santa Barbara 93106.

CALIFORNIA INSTITUTE OF TECHNOLOGY GRADUATE STUDY IN CHEMICAL ENGINEERING

The Division of Chemistry and Chemical Engineering Offers Programs of Advanced Study and Research Leading to the Degrees of Master of Science and Doctor of Philosophy in Chemical Engineering

PROGRAM OF STUDY Distinctive features of study in chemical engineering at the California Institute of Technology are the creative research atmosphere in which the student finds himself and the strong emphasis on basic chemical, physical and mathematical disciplines in his program of study. In this way a student can properly prepare himself for a productive career of research, development, or teaching in a rapidly changing and expanding technological society.

A course of study is selected in consultation with one or more of the faculty listed below. Required courses are minimal. The Master of Science degree is normally completed in one academic year and a thesis is not required. The Ph.D. degree requires a minimum of three years subsequent to the B.S. degree, consisting of thesis research and further advanced study. FINANCIAL ASSISTANCE Graduate students are supported by fellowship, research assistantship, or teaching assistantship appointments during both the academic year and the summer months. A student may carry a full load of graduate study and research in addition to any assigned assistantship duties.

APPLICATIONS Further information and an application form may be obtained by writing

> Prof. C. J. Pings Executive Officer for Chemical Engineering California Institute of Technology Pasadena, California 91109

It is advisable to submit applications before February 15, 1971.

FACULTY IN CHEMICAL ENGINEERING

- WILLIAM H. CORCORAN, Professor and Vice president for Institute Relations Ph.D. (1948), California Institute of Technology Kinetics and catalysis; gas chromatography; plasma chemistry.
- SHELDON K. FRIEDLANDER, Professor Ph.D. (1954), University of Illinois Aerosol physics; particle-surface interactions; interfacial transfer; diffusion and membrane transport.
- GEORGE R. GAVALAS, Associate Professor Ph.D. (1964), University of Minnesota Mathematical methods applied to problems of chemical reactions and transport, process dynamics and control.
- L. GARY LEAL, Assistant Professor Ph.D. (1969), Stanford University Fluid mechanics; rheology.
- CORNELIUS J. PINGS, Professor and Executive Officer Ph.D. (1955), California Institute of Technology

Liquid state physics and chemistry; statistical mechanics.

- BRUCE H. SAGE, Research Associate Ph.D. (1934), California Institute of Technology Eng.D. (1953), New Mexico State College.
- JOHN H. SEINFELD, Associate Professor Ph.D. (1967), Princeton University Optimization and systems studies in chemical process control.
- FRED H. SHAIR, Associate Professor Ph.D. (1963), University of California, Berkeley Phenomena associated with magnetohydrodynamic power generation; chemical reactions and diffusion in electrical discharges.
- NICHOLAS W. TSCHOEGL, Professor Ph.D. (1958), University of New South Wales Mechanical properties of polymeric materials and dilute polymer solutions.
- ROBERT W. VAUGHAN, Assistant Professor Ph.D. (1967), University of Illinois Solid state chemistry and physics, particularly effects of high pressure.

CASE WESTERN RESERVE UNIVERSITY

CASE INSTITUTE OF TECHNOLOGY, a privately endowed institution with a tradition of excellence in Engineering and Applied Science has long offered a variety of courses and research areas



Students interested in graduate work in Chemical Engineering or Applied Chemistry should consider the varied opportunities available in the Chemical Engineering Science Division. Of special interest are strong programs in systems optimization and control, pollution, catalysis and surface chemistry, polymer science and engineering, biomedical engineering, mass transfer, reactor design, and others. Within these broad categories are many individual research projects and course offerings.

FINANCIAL

ASSISTANCE

Graduate Assistantships are offered with stipends ranging from \$400 to \$500 per month (depending on background and marital status) from which \$170 per month tuition charge is deducted. Appointments are made by either the academic or the calendar year.

Fellowships and Traineeships are available providing stipends from \$200 to \$350 per month plus full tuition. Additional allowances for teaching and for dependents are included with some.

Predoctoral loans of substantial amounts are available.

FOR FURTHER **INFORMATION YOU ARE INVITED TO WRITE:**

ROBERT J. ADLER, Head Chemical Engineering Science Division School of Engineering **Case Western Reserve University University** Circle Cleveland, Ohio 44106



--and relax

A year-round recreation setting in the Rockies provides an interesting backyard for the Colorado School of Mines (CSM) in Golden.

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Financial aid is available: industrial fellowships, NSF traineeships, teaching and research assistantships, and sum-



mer support. Graduate student support ranges from \$250-\$400 per month.

For information, contact Dr. J. H. Gary, Department of Chemical and Petroleum-Refining Engineering, Colorado School of Mines, Golden, Colorado 80401.

Colorado School of Mines

Golden, Colorado 80401

Teaching & research faculty:

- Dr. J. H. Gary, Head Petroleum refining Coal technology Oil shale research
- Dr. P. F. Dickson Reactor design Heat transfer Asphalt technology
- Dr. F. J. Stermole Applied mathematics Engineering economics Phase change technology
- Dr. J. O. Golden Fluid mechanics Heat transfer Polymers
- Dr. A. J. Kidnay Thermodynamics Cryogenics Mass transfer
- Prof. E. Shimoda Fluid mechanics Process control Computer technology
- Mr. J. Thomas Electron microscopy Process control Instrumentation

THE UNIVERSITY OF CONNECTICUT

Graduate research programs at The University of Connecticut are focused in areas which we believe will be the center of Chemical Engineering activity in the future. As examples: Studies of chemical processes for treatment and purification of polluted water are underway. This program started four years ago, and is presently supported by a \$161,000 grant from the Federal Water Quality Administration. Studies of the bonding of space-age adhesives to metals are also in progress. Concurrent studies of the flow behavior and morphology of polymers are directed toward technological needs of the chemical industry. Catalytic oxidation of automotive air pollutants and the mechanism of catalytic activity are under study. Research is also underway on applications of computers to



process simulation and control. These are only a few examples taken from a wide spectrum of programs which are intended to train engineers for the jobs and needs of the future. A favorable faculty-to-student ratio ensures that students receive considerable individual attention, both in courses and research. Courses in environmental engineering, polymer science, etc., are offered in addition to the more conventional courses.

Location

The University is located in a picturesque part of New England, free from the pressures of large urban areas, yet just thirty minutes by car from Hartford, one and a half hours from Boston, and three hours from New York City.

FACULTY

James P. Bell, Sc.D. Massachusetts Institute of Technology C. O. Bennett, D.Eng., Yale University

Michael B. Cutlip, Ph.D. University of Colorado

G. Michael Howard, Ph.D. The University of Connecticut

Herbert E. Klei, Ph.D. *The University of Connecticut* Richard M. Stephenson, Ph.D.

Cornell University

L. F. Stutzman, Ph.D., U. of Pittsburgh Donald W. Sundstrom, Ph.D. University of Michigan

Financial Aid

Financial aid is provided to qualified graduate students. Stipends range to \$3975 for the academic year. Summer fellowships and assistantships are available.

For further information and applications, write to:

Graduate Admissions Committee Chemical Engineering Department The University of Connecticut Storrs, Connecticut 06268





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GRADUATE PROGRAMS IN SCIENCE AND SYSTEMS

Since many of you are interested in industrial careers in development and design, while others intend to teach and do basic research our graduate program is divided into two main areas and several interdisciplinary activities.

CHEMICAL ENGINEERING SCIENCE Transport phenomena Fluid dynamics Thermodynamics Kinetics Materials science Applied Math

CHEMICAL ENGINEERING SYSTEMS Chemical reaction engineering Process dynamics Separations processes Process control Computer aided design Optimization

INTERDISCIPLINARY

Energy conversion	Polymer science
Biomedical	Process economics
Interfacial Phenomena	Bioengineering

DIVERSIFIED DEGREE PROGRAMS

- Master of Engineering with project on design, cost analysis, experimental investigation, or computer study.
- Master of Science with thesis.
- · Master of Engineering Pre-Ph.D.
- Doctor of Philosophy.



BASIC GRADUATE COURSES

Models and Methods • Multidimensional and Discrete Systems • Thermodynamics of Reaction and Phase Equilibria • Transport Phenomena • Process Dynamics • Reactor Design and Optimization (Systems Program) or Chemical Kinetics (Science Program)

TYPICAL ADDITIONAL COURSES

Mathematical Methods in Chemical Engineering • Applied Field Theory • Computer Control of Processes · Optimization Techniques · Transport Properties and Irreversible Thermodynamics · Applied Statistical Mechanics · Statistical Thermodynamics • Interfacial Transport Phenomena • Turbulent Transport Phenomena • Advanced Transport Phenomena Rheology • Non-Newtonian Fluids Dynamics · Chemical Energy Conversion · Particulate Systems • Applied Fluid Dynamics • Process System Laboratory • Applied Statistics • Process and Plant Design . Process Economy Analysis • Tensor Fields and Fluid Dynamics Biochemical Engineering • Interfacial Phenomena

Chairman, Chemical Engineering Department University of Florida Gainesville, Florida 32601

Please send information on your graduate program to:

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INQUIRIES ARE DIRECTED TO:

Head, Graduate Admissions Department of Chemical Engineering University of Houston Houston, Texas 77004

REALIZE YOUR POTENTIAL

AT THE UNIVERSITY OF HOUSTON DIVERSIFIED PROGRAMS

The program is designed to meet the individual needs of the student. Flexibility is maintained by minimizing required courses and by offering a wide variety of degree options; M.S. (undesignated), M.E. (professional, non-thesis degree), M.S. (chemical engineering), Ph.D.

STIMULATING RESEARCH . . .

The research interests of the faculty encompass the entire spectrum of chemical engineering endeavors as well as the newer interdisciplinary areas such as environmental, biomedical oceanographic, systems and urban engineering. The student is free to choose research advisors from other departments of the University.

ESTABLISHED DEPARTMENT . . .

Though relatively young, the Department enjoys an outstanding reputation. In 1968 it was awarded an NSF Center of Excellence Grant, and it has achieved high ratings in the 1970 Carter survey of graduate schools.

EXCELLENT FACILITIES

The Department occupies approximately 52,000 sq. ft. in the modern new Cullen College of Engineering Building. Graduate students are allotted individual offices and laboratories and have free access to the University's 1108 Univac and the College's IBM 360 Model 44 computers.

FINANCIAL ASSISTANCE . . .

Fellowship stipends are available to qualified applicants. These range from \$3,000 to \$5,400 for 12 months, plus tuition and fees.

GRADUATE STUDY AND RESEARCH The Department of Energy Engineering UNIVERSITY OF ILLINOIS AT CHICAGO CIRCLE

Graduate Programs in The Department of Energy Engineering leading to the degrees of MASTER OF SCIENCE and DOCTOR OF PHILOSOPHY



Lyndon R. Babcock, Ph.D., University of Washington, 1970, Associate Professor

David S. Hacker, Ph.D., Northwestern University, 1954, Associate Professor

James P. Hartnett, Ph.D., University of California, Berkeley, 1954, Professor and Head of the Department

> John H. Kiefer, Ph.D., Cornell, 1961, Associate Professor

G. Ali Mansoori, Ph.D., University of Oklahoma, 1969, Assistant Professor

Satish C. Saxena, Ph.D., Calcutta University, India, 1956, Professor

Stephen Szépe, Ph.D., Illinois Institute of Technology, 1966, Associate Professor

The Department invites applications for admission and support from all qualified candidates. To obtain application forms or to request further information, please write to:



Air pollution modeling; environmental problems; polymerization.

High temperature chemical kinetics; combustion and plasma processes; simultaneous transport phenomena.

Forced convection; mass transfer cooling; combined radiation-convection problems.

Kinetics of gas reactions; energy transport processes.

Thermodynamics and statistical mechanics of fluids, solids and solutions; kinetics of liquid reactions.

Transport properties of fluids and solids; thermodynamics and statistical mechanics; isotope separation.

Catalysis; chemical reaction engineering, optimization: environmental and pollution problems.

Professor Paul M. Chung, Chairman The Graduate Committee Department of Energy Engineering University of Illinois at Chicago Circle Box 4348, Chicago, Illinois 60680



Iowa State University in Ames, Iowa, the first school to be established under the I862 Land Grant Act, has a long tradition of leadership in Engineering and Applied Science. Today it ranks seventh in the nation in Ph.D. degrees granted in Engineering and ninth in degrees in Chemical Engineering. Its College of Engineering is the largest west of the Mississippi River.

To those interested in Chemical Engineering, Iowa State offers a variety of courses and research areas leading to the M.E., M.S. and Ph.D. degrees. The Department of Chemical Engineering is one of the oldest in the United States and enjoys a rich heritage of excellence in teaching and research. The staff numbers 22 and the enrollment consists of 300 undergraduate and 70 graduate students.

In addition to facilities available in a new Chemical Engineering building, research is conducted in the Ames Laboratory, a National Laboratory of the US Atomic Energy Commission, located on the Iowa State campus. A staff of nearly 1,000 at the Laboratory conducts basic research of long-range interest to the nuclear industry.

Ames lies amid the gently rolling hills of central lowa. Typical of the picturesque yet modern campus is the new cultural center shown above, now half complete. This fall the Festival of Concerts at the center auditorium was opened by the New York Philharmonic. The 14,000-seat coliseum will host many Big Eight Conference athletic events.

A large variety of assistantships and fellowships are filled each year by new graduate students in Chemical Engineering. Living accomodations are available for single students in a new eight-story graduate dormitory, and for married students in more than 1300 apartments operated by the University.

George Burnet, Head	enartment		
Iowa State University			
Ames, Iowa 50010			
Please send application f	orms and further information on y	our graduate program.	
Please send application f	orms and further information on y Undergradua	our graduate program. te School	
Please send application f Name Number and Street	orms and further information on y	our graduate program. te School	

UNIVERSITY OF KENTUCKY

M.S. and Ph.D. Study in Chemical Engineering

including

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> Contact: Robert B. Grieves Dep't of Chemical Engineering University of Kentucky Lexington, Kentucky 40506

FALL 1970

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DEPARTMENT OF CHEMICAL ENGINEERING

UNIVERSITY OF MARYLAND

COLLEGE PARK, MARYLAND 20740

The Department offers graduate work in chemical, materials, and nuclear engineering leading to the M.S. and Ph.D. degrees. Some of the fields of specialization of the faculty are:

Chemical Engineering

Process Control Systems Heat and Mass Transfer Turbulent Transport Solvent Extraction Design and Cost Studies Reaction Kinetics Catalysis Multiphase Flow Process Dynamics Computer Simulation

Biological and

Environmental Engineering

Aerosol Mechanics Membrane Separations Artificial Organs Bioengineering Environmental Health Air Pollution Control

Nuclear Engineering

Nuclear Reactor Physics Nuclear Reactor Design Nuclear Reactor Operation Radiation Induced Reactions System Dynamics Radiation Shielding Radiation Engineering Thermionics

Engineering Materials

Reaction of Solid Surfaces Solid State Behavior Composite Materials Statistical Thermodynamics Structure of Metallic Solutions

Applied Polymer Science

Polymer Physics Graft Polymerization Polymerization Kinetics Non-Newtonian Flow

The general requirements are set forth in the Graduate Catalog. The chemical engineering program is designed for qualified bachelors chemical engineering students. The materials and nuclear engineering programs are open to qualified students holding bachelors degrees in engineering, the physical sciences, and mathematics.

Address inquiries to

Dean, Graduate School or Chairman Department of Chemical Engineering

THE UNIVERSITY OF MICHIGAN OFFERS

EXPERIENCE

The University of Michigan, Department of Chemical and Metallurgical Engineering, has operated graduate degree programs for over 50 years. We have awarded over 300 doctorates and 1000 master's degrees.

VARIED RESEARCH

The 35 faculty members work in all the traditional areas of research and also such fields as plasma reactions, process dynamics, catalyst structure, biochemical processes, electrochemistry, multi-phase systems, computer-assisted design, non-Newtonian fluids, and reservoir engineering.

CULTURAL ENVIRONMENT

Besides the usual campus activities the University and the Ann Arbor community offers the students scores of concerts by famous artists, lectures held throughout the year, plus the three drama series all handy to campus. Ann Arbor is located in a river valley and is ideal for both winter and summer sports.

FINANCIAL ASSISTANCE

Most of our American and Canadian students receive financial assistance. Also, the University has excellent employment opportunities for student wives.

Write for information and a special book to:

Prof. Rane L. Curl, Chairman of the Graduate Committee Chemical Engineering Division Department of Chemical and Metallurgical Engineering The University of Michigan Ann Arbor, Michigan 48104

What are

YOU

looking for

in a

GRADUATE

PROGRAM?



Department of Chemical Engineering

UNIVERSITY OF MISSOURI - ROLLA

ROLLA, MISSOURI 65401

Contact Dr. M. R. Strunk, Chairman

Day Programs

M.S. and Ph.D. Degrees

Established fields of specialization in which research programs are in progress are:

- (1) Fluid Turbulence and Drag Reduction Studies —Drs. J. L. Zakin and G. K. Patterson
- (2) Electrochemistry and Fuel Cells—Dr. J. W. Johnson
- (3) Heat Transfer (Cryogenics) Dr. E. L. Park, Jr.
- (4) Mass Transfer Studies-Dr. R. M. Wellek
- (5) Structure and Properties of Polymers–Dr. K. G. Mayhan

In addition, research projects are being carried out in the following areas:

- (a) Optimization of Chemical Systems—Dr. J. L. Gaddy
- (b) Evaporation through non-Wettable Porous Membranes–Dr. M. E. Findley
- (c) Multi-component Distillation Efficiencies-Dr. R. C. Waggoner
- (d) Gas Permeability Studies—Dr. R. A. Primrose
- (e) Separations by Electrodialysis Techniques— Dr. H. H. Grice
- (f) Process Dynamics and Control–Drs. M. E. Findley, and R. C. Waggoner
- (g) Transport Properties and Kinetics–Dr. O. K. Crosser
- (h) Thermodynamics, Vapor-Liquid Equilibrium —Dr. D. B. Manley



Financial aid is obtainable in the form of Graduate and Research Assistantships, Industrial Fellowships and Federal Sponsored Programs. Aid is also obtainable through the Materials Research Center.



GRADUATE STUDY

IN

CHEMICAL ENGINEERING

AT THE

UNIVERSITY OF NEBRASKA

PROGRAMS LEADING TO THE M.S. AND PH.D. DEGREES WITH RESEARCH IN

Biochemical Engineering Computer Applications Crystallization Desalination Food Processing Heat Transfer Kinetics Laser Applications Mass Transfer Mixing Polymerization Thermodynamics Ultrasonics and other areas

FOR APPLICATIONS AND INFORMATION ON AVAILABLE FINANCIAL ASSISTANCE

WRITE TO

Prof. J. H. Weber, *Chairman* Department of Chemical Engineering University of Nebraska Lincoln, Nebraska 68508



THE UNIVERSITY OF OTTAWA offers a full program of studies and research leading the the masters and Ph.D. degrees in chemical engineering. Well equipped laboratories and modern facilities reside in a recently completed engineering complex. Extensive computing facilities, including an IBM 360/65, are used for course work and research. The staff includes seven full-time professors offering graduate courses and directing research. The graduate program has operated for fifteen years.

CURRENT RESEARCH

- Drag reduction phenomena in turbulent flow
- Viscoelastic effects in flow through porous media
- Membrane separations
- Phase equilibria at cryogenic temperature
- Foam separation of metallic ion pollutants
- Development of selective heterogeneous catalysts
- Mass transfer with reaction
- Polymerization kinetics
- Computer control of chemical processes
- Bio-oxidation in water recovery

THE UNIVERSITY

The University of Ottawa offers instruction in engineering, science, social sciences, and the humanities to a coeducational student body numbering about 7,000. It is situated in Canada's capital, Ottawa, whose population is 400,000.

FINANCES

Fellowships, Teaching Assistantships, and Research Assistantships are available. Minimum graduate student support is \$3,000, and increments are made annually.

CULTURE AND RECREATION

The bilingualism of Canada is reflected in the cultural offerings of Ottawa, featuring renowned performers in the English and French langueges. World famous orchestras, ballet companies, and art exhibitions appear regularly in the National Arts Center.

Ample opportunities for outdoor recreation exist in the Ottawa environs. Several skiing facilities are within 20 miles of the campus,

FURTHER INFORMATION: Address inquiries to: Chairman, Department of Chemical Engineering, University of Ottawa, OTTAWA 2, Canada.

LOOKING



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WRITE TO

Prof. Lee C. Eagleton, Head 160 Chemical Engineering Building The Pennsylvania State University University Park, Pa. 16802

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GRADUATE STUDY IN CHEMICAL AND PETROLEUM ENGINEERING

University of Pittsburgh 11. M.S. and Ph.D. Degrees

PROGRAM

Chemical and Petroleum Engineering is one of six School of Engineering departments which offer graduate degrees. Interdisciplinary programs with other engineering departments and with other PITT schools and divisions such as Public Health, Natural Sciences and Medicine are encouraged.

Courses begin in September, January and April; graduate students may enter in any term.

FINANCIAL ASSISTANCE

Graduate assistantships, research assistantships, fellowships and tuition scholarships are available to qualified students.

Financial support is prowided by the University, industry, and various government agencies. Among sponsors of current research programs are Petroleum Research Fund, National Science Foundation, U.S. Department of Agriculture, National Aeronautics and Space Administration, and United States Steel Corporation.

For application forms and detailed information on FEL-LOWSHIPS, ASSISTANT-SHIPS, and ACADEMIC AND **RESEARCH PROGRAMS, write** to:

Graduate Coordinator Chemical and Petroleum Engineering Department 601 Engineering Hall University of Pittsburgh Pittsburgh, Pennsylvania 15213

FACULTY AND FIELDS OF RESEARCH

IN CHEMICAL ENGINEERING

Dr. Charles S. Beroes Gas Dynamics, Process Design & Optimization. Unsteady State Heaf Transmission Thermodynamics, Mass Transfer Dr. Alan J. Brainard Applied Mathematics Dr., George D. Byrne Mass Transfer, Interfacial Phynomena Dr. Shiao-Hung Chiang Air Pollution Chemical Kinetics, Catalysis, Polymers, Dr. Morton Corn Dr. James Coull Thermogravitational Separation Dr. Benjamin Gal-Or Transport Phenomena; **Relativistic Thermodynamics** Dr. Harold E. Hoelscher Reaction Kinetics, Interfacial Phenomena Fluid Dynamics, Transport Phenomena Dr. George E. Klinzing Electrochemical Engineering Dr. Chung-Chiun Liu Transport Phenomena Dr. Yatish T. Shah Dr. Edward B. Stuart Thermodynamics, Adsorption Process Dynamics, Dr. John W. Tierney Equilibrium Stage Calculations Dr. Lemuel B. Wingard Biomedical Engineering, **Enzyme Catalysis**

IN PETROLEUM ENGINEERING

Prof. James H. Hartsock

Dr. Paul F. Fulton Multiphase Flow in Porous Media, Wettability **Computer Applications** to Unsteady State Flow Dr. Joseph J. Taber Interfacial and Surface Phenomena, Miscible Displacement

GRADUATE STUDY IN CHEMICAL ENGINEERING AT RICE UNIVERSITY

The Department

Rated by the American Council of Education among the top 15 Chemical Engineering Departments in the U. S. It has:

- 35 graduate students
- 10 postdoctoral fellows and research associates
- 12 full-time faculty
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The University

Full University with programs in health and social sciences and humanities, as well as engineering.

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Major Research Areas

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Degree Programs

M.S. and Ph.D. degrees offered in Chemical Engineering.

Interdisciplinary programs in Biomedical Engineering and Polymer Science.

FALL 1970



Faculty

- W W. Akers, Ph.D., U. of Texas, Professor
- C. D. Armeniades, Ph.D., C.W.R.U., Asst. Prof.
- S. H. Davis, Jr., Sc.D., M.I.T., Professor
- H. A. Deans, Ph.D., Rice U., Professor
- D. C. Dyson, Ph.D., U. of London, Asso. Professor
- G. D. Fisher, Ph.D., Johns Hopkins U., Asst. Prof.
- J. D. Hellums, Ph.D., U. of Texas, Professor
- J. W. Hightower, Ph.D., Johns Hopkins U., Prof.
- R. Jackson, D.Sc., U. of Edinburgh, Professor
- R. Kobayashi, Ph.D., U. of Michigan, Professor
- T. W. Leland, Jr., Ph.D., U. of Michigan, Prof.
- L. V. McIntire, Ph.D., Princeton U., Asst. Prof.

Financial Support

Fellowships and assistantships are available with tuition remission and stipends competitive with other major universities.

Graduate assistants' duties require less than 6 hours per week and allow full-time study load.

Applications

Address letters of inquiry to:

Dr. C. D. Armeniades, Assistant Professor Department of Chemical Engineering Rice University Houston, Texas 77001

AT THE UNIVERSITY OF TENNESSEE GRADUATE STUDY IN CHEMICAL & METALLURGICAL ENGINEERING

PROGRAMS for the degrees of Master of Science and Doctor of Philosophy are offered in both chemical and metallurgical engineering. The Master's program may be tailored as a terminal one with emphasis on systems and design, or it may serve as preparation for more advanced work leading to the Doctorate.



ACULTY AND RESEARCH INTERESTS — William T. Becker, Ph.D., Illinois, Mechanical Properties and Deformation; Donald C. Bogue, Ph.D., Delaware, Rheology, Polymer Science and Engineering; Charlie R. Brooks, Ph.D., Tennessee, Electron Microscopy, Thermodynamics; Oran L. Culberson, Ph.D., Texas, Operations Research, Process Design; George C. Frazier, Jr., D. Eng., Johns Hopkins, Kinetics and Combustion, Transfer with Reaction; Hsien-Wen Hsu, Ph.D., Wisconsin, Thermodynamics, Transport Phenomena, Optimization; Homer F. Johnson, D. Eng., Yale, (Department Head), Mass Transfer, Interface Phenomena; Stanley H. Jury, Ph.D., Cincinnati, Sorption Kinetics, Hygrometry, Information Operations; William J. Kooyman, Ph.D., Johns Hopkins, Reaction Kinetics in Flow Systems; Carl D. Lundin, Ph.D., Rensselaer, Physical Metallurgy, Welding; Charles F. Moore, Ph.D., L.S.U., Process Control and Dynamics; Ben F. Oliver, Ph.D., Pennsylvania State University, (Professor-in-charge of Metallurgical Engineering), Solidification, High Purity Metals; Joseph J. Perona, Ph.D., Northwestern, Mass Transfer and Kinetics, Heat Transfer; Joseph E. Spruiell, Ph.D., Tennessee, X-ray Diffraction, Electron Microscopy, Polymer Science and Engineering; E. Eugene Stansbury, Ph. D., Cincinnati, Thermodynamics Kinetics of Phase Deformation, Corrosion; James L. White, Ph.D., Delaware, Polymer Science and Engineering, Rheology, Separation Processes.

R EGULAR PART-TIME—Lloyd G. Alexander, Ph.D., Purdue, Fluid Flow, Heat Transfer; Bernard S. Borie, Ph.D., M.I.T., X-ray Diffraction; Albert H. Cooper, Ph.D., Michigan State, Process Design, Economics; Kenneth H. McCorkle, Ph.D., Tennessee, Colloidal Systems; Carl J. McHargue, Ph.D., Kentucky, Physical Metallurgy; Roy A. Vandermeer, Ph.D., Illinois Institute of Technology, Physical Metallurgy, Jack S. Watson, Ph.D., Tennessee, Fluid Mechanics.

LABORATORIES AND SHOPS—Analog computer (Expanded EAI, PACE 221R) and digital computer (DEC, PDP 15/20 with analog interface), High-speed automatic frost point hygrometer, Mass and heat transfer in porous media, Polymer rheology (Weissenberg rheogoniometer, Instron rheological tester, roll mill, extruder). Polymer characterization (gel permeation chromatograph, osmometer), Mass spectograph, Continuous zone centrifuge, Process dynamics, X-ray diffraction (including single crystal diffuse scattering analysis), Electron microscopes (Philips EM75 EM300), Calorimetry (25-1000°C), Electrical resistivity measurements for studies of structural and phase changes, Single crystal preparation facilities, Mechanical fabrication and testing, (metallograph, optical microscopes and melting, etc.), High purity materials preparation, Electronic and mechanical shops staffed by thirteen full-time technicians and craftsmen.

FINANCIAL ASSISTANCE—Sources available include graduate assistantships, graduate teaching assistantships, research assistantships, industrial fellowships, industrial grants-in-aid, NSF Traineeships, NDEA (Title IV) Fellowships, and University Non-Service Fellowships.

COSTS TO STUDENTS—Full-time Tennessee residents pay \$105 per quarter maintenance fee; out-of-state students pay an additional tuition of \$205 per quarter; combined room-and-board arrangements are available at \$305 per quarter. One- and two-bedroom married student apartments rent from \$60 to \$110 per month unfurnished, approximately \$15 higher furnished. Privately operated apartments are available to single or married graduate students at equivalent and higher rates.

S TUDENT BODY—About 20,000 students are enrolled at the Knoxville campus. In the College of Engineering there are approximately 2200 undergraduate and 300 resident graduate students.

K NOXVILLE AND SURROUNDINGS—Knoxville, with a population near 200,000, is the trade and industrial center of East Tennessee. The University is located about five blocks from the downtown business area. In the nearby Auditorium-Coliseum, Broadway plays, musical and dramatic artists, and other entertainment events are regularly scheduled. Knoxville has a number of points of historical interest, a theater-in-the-round, a symphony orchestra, two art galleries, and a number of museums. Within an hour's drive are many TVA lakes and mountain streams for water sports; the Great Smoky Mountains National Park with the Gatlinburg tourist area; two state parks; and the atomic energy installations at Oak Ridge including the Museum of Atomic Energy.

ABOUT UT-Founded in 1794 as Blount College, the University has grown to a large multicampus, multi-purpose system of higher education covering the entire state. Graduate programs in science and engineering centered at the Knoxville campus have developed to major size and strength over the past 25 years stimulated by cooperation developed between the atomic energy facilities and the University.

WRITE: Department of Chemical and Metallurgical Engineering The University of Tennessee Knoxville, Tennessee 37916

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Faculty

E.B. CHRISTIANSEN, Prof. and Chm.; PhD, U of Michigan. Newtonian and non-Newtonian momentum and energy transport, particle dynamics, biological transport processes.

A.D. BAER, Prof.; PhD, U of Utah. Heat transfer, fluid dynamics, process control, combustion.

R.H. BOYD, Prof.; PhD, MIT. Polymer and materials science, chemical thermodynamics.

N.W. RYAN, Prof.; ScD, MIT. Combustion, high-temperature reactions, gas dynamics, propulsion.

D.L. SALT, Prof.; PhD, U of Delaware. Diffusional operations, fluid and particle dynamics, separation processes.

J.D. SEADER, Prof.; PhD, U of Wisconsin. Coupled chemical-reaction kinetics, momentum, energy, and mass transport; ablation; polymer flammability; systems; design.

N.H. de NEVERS, Assoc. Prof. and Assoc. Dean; PhD, U of Michigan. Thermodynamics, multi-phase flow, chromatographic transport.

A.L. TYLER, Assist. Prof.; PhD, U of Utah. Chemicalreaction kinetics, particle dynamics, vapor-phase reactions, solid-state diffusion.

Assistance & Application

The Department offers NDEA Fellowships, NSF and Environmental-Pollution Traineeships, and a variety of research, design, and teaching assistantships to qualified applicants. Application materials and further information may be obtained by sending the coupon below to:

Dr. E. B. Christiansen, Chairman Department of Chemical Engineering University of Utah Salt Lake City, Utah 84112

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FOR INFORMATION CONTACT

Dr. Richard W. Hanks 234 ELB, Chemical Engineering Brigham Young University Provo, Utah 84601



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Graduate Student Advisor Department of Chemical Engineering University of California Davis, California 95616



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- W. B. Harris, Flow Through Porous Media W. D. Harris, Heat Transfer
- W. D. Harlis, Ital Harlister Properties of Mixtures
 W. W. Meinke, Bio-Engineering
 E. A. Schweikert, Activation Analysis

- R. E. Wainerdi, Activation Analysis

For information concerning the graduate program contact Dr. P. T. Eubank, Graduate Advisor, Texas A&M University, Department of Chemical Engineering, College Station, Texas 77843



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Chairman, Graduate Committee Chemical Engineering Department University of Colorado, Boulder

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The staff of CEE wishes to thank the 51 departments whose advertisements appear in this second graduate issue. We also appreciate the excellent response you gave to our request for names of prospective authors. We re-gret that, because of space limitations, we were not able to include some outstanding papers and that certain areas are not represented. In part our selection of papers was based on a desire to complement this issue with that of 1969, for we hope that seniors interested in graduate school will read both issues. As indicated in our letter of September 1, we are sending automatically to each department at least sufficient free copies of this issue for 1/5 the number of bachelor's degrees reported in "ChE Faculties". Because of the large number of requests you made for extra copies for seniors and graduate students, we were forced to limit the number of these to the total number of bachelor's degrees your department reported. However if you have definite need for more copies than you received, we may be able to furnish these upon request.

During the three years CEE has been published at the University of Florida its support has been derived pri-marily from industrial advertisers and donors. Unfortunately that source of support is now decreasing rapidlydue to economic reasons. For example, while CEE's in-come from industrial sources was \$9,240 in 1969, it is expected to be only \$7,300 in 1970 and recent trends indicate that our industrial support in 1971 may be as low as \$2,000—or a drop of \$7,240. Since the bulk of our sup-port has come from industrial sources, it will be more important than ever for departments and faculty members to assist us through bulk and individual subscrip-tions. We are very appreciative that we have had the support of 123 departments in 1970, and we like to urge you not only to continue your support in 1971, but also to see if it can be increased by ordering additional copies, these may be used as follows:

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Please keep in mind that payment for these bulk subscriptions (at \$4.00 each with \$25 minimum for 6 copies or fewer) may be made by any of the following means (or combination thereof); (1) Direct payment by check from departmental funds. (2) Payment by check after

solicitation from the faculty of individual contributions and (3) Payment from university funds after being billed. You may order your copies from Dr. R. B. Bennett, CEE Business Manager, Department of Chemical Engi-neering, University of Florida, Gainesville, Florida. 32601. Ray Fahen, Editor

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