ENGINEERING (Ph.D.)

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Note: The Ph.D. Program in Engineering at the Graduate Center is no longer accepting any new applications. The Graduate Center is providing the opportunity for continuing students to complete their degrees. Prospective students may apply to the Grove School of Engineering at The City College of the City University of New York. See http://www1.ccny.cuny.edu/prospective/engineering/. For information, please contact Professor Mumtaz Kassir: Kassir@ccny.cuny.edu.

FACULTY (AS OF JULY 2009)

Anil Kumar Agrawal ■ Samir A. Ahmed ■ Daniel L. Akins ■ Harold Alexander ■ Robert R. Alfano ■ Mohamed A. Ali ■ Yiannis Andreopoulos ■ Neophytos Antoniades ■ Sanjoy Banerjee ■ Charusheel N. Bapat ■ Joseph Barba ■ Marom Bikson ■ Adele L. Boskey ■ Candido Cabo ■ Nancy Camacho ■ Raymond L. Camisa ■ Luis Cardoso Landa ■ Cynthia Chen ■ Michael Conner ■ Alexander Couzis ■ Stephen Cowin ■ David T. Crouse ■ Zeev Dagan ■ Feridun Delale ■ Morton M. Denn ■ Vasil Diyamandoglu ■ Roger Dorsinville ■ Erlan H. Feria ■ John Fillos ■ Susannah P. Fritton ■ Bimgmei M. Fu ■ Peter Ganatos ■ Swapan Kumar Gayen ■ Michel Ghosn ■ M. Lane Gilchrist ■ Barry Gross ■ Marilyn R. Gunner ■ Ibrahim W. Habib ■ Robert M. Haralick ■ Ping-Pei Ho ■ Vern L. Houston ■ Leslie L. Isaacs ■ Kung-Ming Jan ■ Karl J. Jepsen ■ Latif M. Jiji ■ Mumtaz K. Kassir ■ Reza Khanbilvardi ■ Joel Koplik ■ George M. Kranc ■ Ilona Kretzschmar ■ Themis Lazaridis ■ Jae Woo Lee ■ Myung Jong Lee ■ Taehun Lee ■ Alfred M. Levine ■ Jacqueline J. Li ■ Lihong (Connie) Li ■ Yao Li ■ Been-Ming Benjamin Liaw ■ Feng-Bao Lin ■ Shayesteh E. Mahani ■ Hernan A. Makse ■ Charles Maldarelli ■ Claire McKnight ■ Jeffrey F. Morris ■ Fred Moshary ■ Truong-Thao Nguyen ■ Robert E. Paaswell ■ Neville A. Parker ■ Lucas C. Parra ■ Vladimir Petricevic ■ Mary J. Potasek ■ Rishi Raj ■ Kaliappa Ravindran ■ Irven H. Rinard ■ Syed A. Rizvi ■ William B. Rossow ■ Leonid Roytman ■ David S. Rumschitzki ■ Tarek N. Saadawi ■ Ali M. Sadegh ■ Mitchell B. Schaffler ■ Norman Scheinberg ■ Mark D. Shattuck ■ Lawrence Sirovich ■ Kenneth Sobel ■ David Conover Spray ■ Carol A. Steiner ■ Kolluru V. Subramaniam ■ Hui Bin (Herb) Sun ■ Yi Sun ■ Maria C. Tamargo ■ Cheuk Y. Tang ■ John M. Tarbell ■ Gabriel Tardos ■ Peter A. Torzilli ■ Raymond S. Tu ■ M. Ümit Uyar ■ Maribel Vásquez ■ Ioana R. Voiculescu ■ Ardie D.

Walser ■ Sihong Wang ■ Charles B. Watkins, Jr. ■ Alan M. Weinstein ■ Ann Elizabeth Wittig ■ George Wolberg ■ John (Jizhong) Xiao ■ Honghui Yu ■ Mohamed M. Zahran
For the most up-to-date faculty listings and specializations, see the program's Web site.

THE PROGRAM

The Ph.D. Program in Engineering prepares selected students for careers in the fields of engineering. Doctoral work in engineering is offered at the School of Engineering of The City College. The following areas of doctoral study are offered: biomedical, chemical, civil, electrical, and mechanical engineering.

Biomedical Engineering

The purpose of biomedical engineering, as an interdisciplinary research discipline, is to apply engineering principles and physical and mathematical concepts to problems in medicine and biology and to contribute to the advancement of technology in cost-effective health and medical care. The goal of our biomedical engineering program is to provide students with an engineering or science background the knowledge and skills with which they can creatively contribute to the technological revolution in medicine and health care that dramatically transformed the prevention, diagnosis, and treatment of disease in the last few decades of the twentieth century.

The program combines course work in the traditional engineering disciplines, specially designed courses in biomedical engineering, mathematical and computational modeling, and the biological sciences; it offers students research opportunities that are at the forefront of the interface between engineering, the biological sciences, and medicine: arterial transport, bioheat transfer, biomechanics of the cervical spine, biosignal processing, bone formation, cardiovascular dynamics, cartilage and soft tissue engineering, design and structural studies of biomaterials, hydrogels for controlled drug release, intercellular communication, lung biology, mechanosensation in bone tissue, microvascular exchange, microfluidic devices, orthopaedic biomechanics, rehabilitation engineering, renal transport, ventricular arrhythmias. This research is conducted in an environment of collaboration among engineers, biological scientists, and health care professionals from both CUNY and some of the premier medical institutions in New York City.

The New York Center for Biomedical Engineering (NYCBE) at the City College of New York was established in 1994 with the support of the Whitaker Foundation to serve as a national urban model for training in biomedical engineering research. It is a consortium of faculty and researchers from:

The City College of New York School of Engineering
CUNY Graduate Center
CUNY Medical School
Albert Einstein College of Medicine
Columbia College of Physicians and Surgeons
The Hospital for Special Surgery/Weill Medical College of Cornell University
Mount Sinai School of Medicine
New York University School of Medicine
Memorial Sloan-Kettering Cancer Center

In addition to the principal partners in the NYCBE, faculty and research staff have collaborations with numerous other medical institutions nationwide and abroad. The NYCBE, a CUNY institute since 1996, provides access to a diverse faculty of nearly 30 researchers in a broad spectrum of research areas.

Chemical Engineering

The program in chemical engineering is actively involved in research pointed toward new understanding and development in the areas of fluid mechanics, controlled drug release, chemical process economics, particle technology, fluid particle systems, soft materials, surface phenomena, self-assembled monolayers, nanotechnology, and biomedical engineering. Graduate study includes courses in chemical engineering fundamentals as well as courses in applications of chemical engineering principles in specific areas such as economics of new processes, fluidization, particle science and technology, and interfacial phenomena.

The Benjamin Levich Institute of Physico-Chemical Hydrodynamics, an internationally recognized research center for the study of fundamental problems of flow and transport in complex fluids, fluid-like media, and interface systems headed by Albert Einstein Professor Morton Denn, includes faculty from the departments of Chemical Engineering, Mechanical Engineering, and Physics. The current scope of the institute's research is in five major areas: granular flows, low Reynolds number hydrodynamics, non-Newtonian fluid mechanics, computational fluid mechanics, and transport along interfaces. Examples include experimental granular kinetic theory, granular compaction, particle migration in concentrated suspensions undergoing shear, the influence of surfactants on the motion of drops and bubbles, microscopic fluid mechanics using molecular dynamics simulations and droplet mechanics in liquid-crystalline polymer blends. The institute has excellent laboratory and computational facilities.

The development of advanced design methods for the practicing chemical engineer is a special interest in the department. These new methods incorporate the achievements of recent chemical engineering research. This approach is applied to both process and chemical reactor design, process control, and process economics.

In biomedical research, the department engages in the transport of macromolecules across arterial walls and their accumulation therein, low Reynolds number hydrodynamics applications to microcirculation, controlled drug release, and the development of biomaterials from cellular components.

Materials research in the department is aimed at an understanding of the production and characterization of optical materials, powder technology, and circulating fluid beds. Research on nanotechnology and nanoscience is based on the adsorption of surfactants at the solid-liquid interface for the purpose of engineering materials with specific surface properties. Applications are made to control of wetting behavior, adhesion, novel sensors, and templated crystallization.

Civil Engineering

The program in civil engineering is actively involved in research in the areas of structural mechanics, water resources, environmental and geotechnical engineering, and transportation. Graduate study includes courses in civil engineering fundamentals as well as courses in analy-

sis and design in a variety of areas covering the various specialties in civil engineering. The department also houses two research institutes and two research centers.

The program in structural mechanics emphasizes the analysis and design of civil engineering structures using analytical and numerical methods. Current research interests include wave propagation and fracture mechanics, behavior of concrete and composite materials, stochastic response of bridges, load modeling and reliability analysis of highway bridges, nondestructive testing, earthquake engineering, civil engineering materials, structural dynamics and control, and computational mechanics.

The City University Institute for Transportation Systems engages in research efforts that are generally interdisciplinary in nature, and the institute provides an opportunity to utilize and coordinate the talents of the faculties at the various campuses of the University system. Current research activities include bus procurement projects dealing with conventional and experimental fuels, private transportation initiatives in the New York metropolitan area, development of a comprehensive dynamic model of urban systems, value capture financing techniques in transportation, an expert system for selection of traffic accident countermeasures, and nondestructive testing of pavement.

The City College Earthquake Engineering Research Center actively pursues basic and applied research in earthquake engineering. Current research activities in the center include stochastic response of bridges under seismic loads, models of nonlinear behavior of structures, structural control, soil liquefaction, and development of design codes for earthquake hazard mitigation.

The Center for Water Resources and Environmental Research engages in basic and applied research in studying various problems of water resources and environment protection, especially those where a multidisciplinary and/or a multinational approach is needed. Current research activities in the center include application of microwave remotely sensed data in detection and classification of wetlands, as well as soil moisture measurements; plume source tracking in rivers and coastal waters; contaminant transport in freezing/thawing soils; application of Geographical Information Systems (GIS) and remote sensing for hydrological evaluation of watersheds; effect of climate changes on water resources; development of new technology for beach protection; mathematical modeling for evaluation and protection of wetlands; fate and transport of radionuclides during surface runoff and soil erosion processes.

The Institute for Municipal Waste Research initiates and coordinates research activities in the area of environmental engineering that include bench, pilot, and demonstration scale evaluations of biological and physicochemical processes for the removal of nutrients from domestic and industrial wastewaters as well as landfill leachates. Additional areas of research include hydrodynamic modeling of rectangular and circular clarifiers to predict and enhance process performance; attached bacterial growth techniques in evaluating biological stability and postdisinfection bacterial regrowth potential in drinking water supplies; effects of various oxidation processes such as ozonation, chlorination, and UV irradiation on biological stability of water; kinetics of organic disinfection by-products (DBP) formation during chlorination and ozonation; and photodecomposition of inorganic DBP as well as organic compounds considered precursors to DBP formation by UV irradiation.

Electrical Engineering

Graduate study in electrical engineering covers a wide range of interests. These include basic studies of electrical, electronic, and photonics processes and phenomena, and their applications, systems research, computer engineering, communications systems and networks, and image and signal processing. The faculty in electrical engineering are engaged in a broad spectrum of research areas. Of particular strength are the areas of photonics engineering, signal and image processing, communications engineering, control theory, and computer engineering.

The Photonics Engineering group's interests are in new laser sources, optical computing, ultrafast phenomena and devices, new optical materials, microstructures, laser remote sensing, quantum optics and electronics, nonlinear optics, and optical diagnostic instruments.

The Signal Processing group is engaged in research in filter design, stability analysis, algorithms for extraction of parameters from radar, X-ray and NMR signals, development of fast algorithms, and image processing.

The Communication Engineering group's activities are in modulation scheme, spread spectrum techniques, error-correcting codes, and data and digital communication.

The Control group is pursuing research in adaptive, modal, nonlinear, and robust control and flight control applications.

The Computer Engineering group's activities are in computer architecture, neural network, computer communications, and local area networks.

The departmental facilities include the Loral Microwave Laboratory, the Hamamatsu Photonics Application Laboratory, the Ultrafast Photonics Laboratory, the Photonics Engineering and Remote Sensing Laboratory, the Optical Computing Laboratory, the Communications Laboratory, the Supercomputation Laboratory, and the Image Processing Laboratory.

Mechanical Engineering

Graduate study in mechanical engineering is organized into fluid mechanics, heat transfer, aerodynamics, theory of machines, biotransport, biomechanics, and solid mechanics and vibrations. Specific opportunities for research and thesis work are offered in dynamics and optimization of machines, turbulence, vortex flow, experimental and computational fluid mechanics, gas dynamics, biofluid mechanics, bioheat and mass transport, heat and mass transfer, turbomachinery, thermal stresses, vibrations, micromechanics, microheat transfer, MEMS, fluid mechanics and heat transfer in porous media, mechanics of skiing, fracture mechanics, composite materials, experimental mechanics, bone mechanics, and boundary and finite element techniques. Facilities for experimental research include wind tunnels, a shock tube, laboratories for heat transfer, turbomachinery, fatigue and fracture of materials, machine dynamics and vibrations, tissue mechanics, microcirculatory flow, manufacturing, and aerodynamics.

Recent acquisitions include a subsonic wind tunnel, a microelectronics cooling facility, high frequency computerized data acquisition systems, a YAG laser, Ar+ laser, laser Doppler velocimeter, global Doppler velocimeter, a shaker, holography equipment, a high-temperature refractory furnace, a universal testing machine, a bone-loading device, and a scanning electron microscope. The research effort in the department is led by several prominent faculty members and has been amply supported with funding from NSF, NIH, ONR, NASA, U.S. Army, ARPA, and AFOSR, as well as industry and local government agencies.

Special Requirements for Admission

In addition to meeting the general University requirements stated earlier in this bulletin, the applicant must have received a bachelor's degree in a branch of engineering or in a closely related area appropriate to the applicant's intended field of study from a college or university of accredited standing and must be adequately prepared in specific courses, as may be required by the individual departments. The applicant's academic record must demonstrate the promise of superior performance in advanced study and research.

Special Requirements for the Doctor of Philosophy

The general University requirements are stated earlier in this bulletin. The special requirements in engineering are as follows.

Course of Study After being notified of admission and preferably before registration, the student should arrange for an appointment with a departmental adviser who will help the student plan an approved sequence of courses, including courses from programs other than engineering. Courses will not be credited toward a degree unless they are part of an approved program. A minimum of 60 credits of approved course work is required for a Ph.D. in engineering.

Research Techniques The student shall demonstrate proficiency in those research techniques considered appropriate by the faculty in the student's field of specialization.

Residence Requirements The student is required to be in residence for the equivalent of six full-time semesters. With the approval of the Executive Officer, a student who possesses a master's degree in engineering, or in a relevant area, from an accredited institution or has completed equivalent graduate work will be required to be in residence for the equivalent of only four full-time semesters. At least two consecutive semesters must be in full-time residence. With the permission of the Executive Officer, students holding research or teaching appointments may study part-time.

Dissertation Before undertaking research work, the student's program of research must be approved by a guidance committee and the appropriate department chair.

Courses

Courses in engineering are listed under the following departments of engineering: Biomedical, Chemical, Civil, Electrical, and Mechanical Engineering, and under the general heading Engineering. It is expected that courses with a departmental designation will usually be given by a member of that department and that usually the class will consist of students associated with that department. Courses listed under the general heading Engineering are expected to be of interest to students specializing in various branches of engineering. The instructors and students for these courses will be drawn from among the several engineering departments. Students are required to have the approval of the adviser before registration to ensure that they have adequate background knowledge and prerequisites. For course descriptions and prerequisites, see *The City College Graduate Bulletin.*

Unless otherwise stated, all courses are *45 hours plus conferences, 3 credits*.

Engineering

ENGR 57060* Applied Algebra
ENGR 57080 Foundations of Fluid Mechanics I
ENGR 57090 Foundations of Fluid Mechanics II
ENGR 57110 Introduction to Engineering Analysis
ENGR 57120* Functions of a Complex Variable
ENGR 57130* Transform Methods in Engineering
ENGR 57140 Applied Partial Differential Equations
ENGR 57150 Introduction to Numerical Methods
ENGR 57160 Advanced Numerical Analysis
ENGR 57170 Finite Element Methods in Engineering
ENGR 57200* Random Processes in Engineering Mechanics
ENGR 57240 Turbulent Flows
ENGR 57320* Statistical Thermodynamics
ENGR 57520 Behavior of Inelastic Bodies and Structures
ENGR 57640 Wave Propagation in Fluids and Solids
ENGR 57910 Mass Transfer
ENGR 58010 Fluid Dynamic Stability
ENGR 58310* Irreversible Thermodynamics
ENGR 58400 Perturbation Techniques
ENGR 58500 Theory of Elasticity

Biomedical Engineering

BM E 55900 Independent Studies and Research in Biomedical Engineering
BM E 57000 Biomedical Engineering Seminar
BM E 57220 Cell and Tissue Transport
BM E 57430 Physiology for Biomedical Engineers
BM E 57500 Biomedical Imaging
BM E 57510 Nonlinear Signal Processing in Biomedicine
BM E 57710 Cell and Tissue Mechanics
BM E 57730 Cell and Tissue-Biomaterial Interactions
BM E 57770 Microfluidic Devices in Biotechnology
BM E 57980 Project
BM E 58990 Research for the Doctoral Dissertation

Chemical Engineering

CH E 54700 Topics in Materials Science and Engineering
CH E 55150 Rheology
CH E 55170 Techniques and Practice of Simulation
CH E 55530 Bioprocess Engineering: Principles and Applications
CH E 55900 Independent Studies and Research in Chemical Engineering
Variable credits, 1-3
CH E 57230 Non-Newtonian Fluids

CH E 57200 Advanced Chemical Thermodynamics
CH E 57300 Chemical Process Simulation
CH E 57320* Statistical Mechanics I
CH E 57330 Advanced Kinetics
CH E 57340 Fluidization
CH E 57350* Statistical Mechanics II
CH E 57410 Chemical Process Economics
CH E 57550 Interfacial Phenomena
CH E 57570 Advanced Materials Engineering
CH E 57610 Polymer Science and Engineering
CH E 57770 Process Dynamics and Control I
CH E 57780 Process Dynamics and Control II
CH E 57860 Separation Operations I
CH E 57880 Separation Operations II
CH E 57890 Nanotechnology
CH E 57900 Bioprocess Engineering
CH E 57910 Mass Transfer

Civil Engineering

C E 55420 GIS Transportation Modeling
C E 55900 Independent Studies and Research in Civil Engineering
Variable credits, 1-3
C E 56010* Introduction to Transportation
C E 56020 Transportation Economics
C E 56210 Flexible and Rigid Pavements
C E 56240 Airport Design and Planning
C E 56260 Rail System Design
C E 56350* Traffic Engineering Studies
C E 56360 Geometric Design of Transportation Facilities
C E 56410 Highway and Airport Construction
C E 56450 Urban Public Transportation
C E 56460 Environmental Issues in Transportation
C E 56520 Bridge Engineering
C E 56530 Advanced Structural Design
C E 56570 Condition Assessment and Rehabilitation of Structures
C E 56610 Advanced Hydraulics
C E 56630 Groundwater Hydrology and Contamination
C E 56650 Statistical Methods in Water Resources
C E 56760 Unit Processes in Environmental Engineering
C E 56840 Solid Waste Management
C E 56900 Advanced Foundation Engineering
C E 56190 Advanced Finite Elements
C E 57200 Travel Demand Forecasting

C E 57230 Pavement Management Systems
C E 57240 Analytical Techniques in Transportation
C E 57260 Urban Transportation Planning
C E 57270 Transportation Policy
C E 57280 Transit Systems: Planning and Operations
C E 57290 Transportation Project Evaluation
C E 57300 Structural Dynamics
C E 57350 Applied Elasticity and Plasticity
C E 57360 Fracture Mechanics
C E 57380* Plates and Shells
C E 57390 Composites in Modern Structure
C E 57400 Traffic Control
C E 57410 Intelligent Transportation Systems (ITS): Fundamentals and Applications
C E 57430* Plastic Analysis and Design of Structures
C E 57450 Advanced Transportation Planning
C E 57470 Planning and Design of Passenger Terminals
C E 57540 Linear and Nonlinear Analysis of Structures
C E 57550* Stability of Structures
C E 57560 Earthquake Engineering
C E 57580 Structural Reliability
C E 57620 Transport in Porous Media
C E 57630 Water Resources Modeling
C E 57700 Wastewater Treatment
C E 57910 Soil Dynamics
C E 57920 Advanced Soil Mechanics
C E 58110* Port Design and Planning
C E 58200* Transportation Planning Models

Electrical Engineering

E E 54500 Microwave Networks
E E 54510 Communication Electronics
E E 54520 Fiber Optic Communications I
E E 54530 Digital Processing of Signals
E E 54540 Physical Electronics
E E 54560 Elements of Control Theory
E E 54570 Electronic Circuits
E E 54580 Introduction to Lasers
E E 54590 Microprocessors
E E 54600 Computer Communication Systems
E E 54620 Photonic Engineering
E E 54630 Wireless Communications
E E 54640 VSLI Design

75 hours (includes 3 hour/week laboratory), 3 credits

E E 55900 Independent Studies and Research in Electrical Engineering
Variable credits, 1-3
E E 55940 High Speed Networks
E E 57010 Probability and Stochastic Processes
E E 57030 Electrodynamics
E E 57040 Signal Theory
E E 57050 Theory of Linear Systems
E E 57080 Physical Electronics II
E E 57120 Cryptology
E E 57140 Knowledge-Based Systems
E E 57160 Digital Signal Processing Algorithms
E E 57170 Theory of Switching Systems I
E E 57180 Theory of Switching Systems II
E E 57190* Radar Signal Processing
E E 57220 Image Processing and Recognition
E E 57230 Digital Computers I
E E 57240 Digital Computers II
E E 57270 Parallel Processing
E E 57320 Analog Integrated Circuits
E E 57360 MOS Devices and Circuits
E E 57410 Introduction to Modern Control Theory
E E 57440 Introduction to Adaptive Control
E E 57450 Theory of Optimal Control
E E 57460 Analysis and Design of Intelligent Systems
E E 57480 Robotics
E E 57600 Communication Protocol Engineering
E E 57610 Integrated Circuits: Design and Fabrication I
E E 57620 Integrated Circuits: Design and Fabrication II
E E 57650 Antenna Theory
EE 57680 Optical Remote Sensing
E E 57700 Local Area Networks
E E 57710 Statistical Communication Theory
E E 57720 Spread Spectrum
E E 57730 Digital Communication I
E E 57740 Digital Communication II
E E 57740 Data Communications
E E 57820 Electro-Optics
E E 57830 Optical Communications
E E 57850 Optical Signal Processing
E E 58260* Advanced Network Theory
E E 58270 Multidimensional Signal Processing
E E 58360 Microwave Electronics
E E 58460* Advanced Topics in Control Theory

E E 58720* Advanced Communication Theory
E E 58730* Signal Detection, Estimation and Modulation
E E 58760* Advanced Information and Coding Theory
E E 58810 Quantum Electronics
E E 58820* Wave Interaction in Solids
E E 58830* Quantum Optics
E E 58840* Kinetic Theory
E E 58850 Nonlinear Optics

Mechanical Engineering

M E 55900 Independent Studies and Research in Mechanical Engineering
Variable credits, 1-3
M E 57190* Lubrication
M E 57220* Applied Fluid Dynamics
M E 57310 Steam and Gas Turbines
M E 57330* Advanced Engineering Thermodynamics
M E 57360 Conduction Heat Transfer
M E 57370 Convection Heat Transfer
M E 57380 Radiation Heat Transfer
M E 57400 Kinematic Analysis of Mechanisms
M E 57410 Kinematic Synthesis of Mechanisms
M E 57540 Advanced Stress Analysis in Machine Components
M E 57560 Advanced Analytical Dynamics
M E 57580* Trajectories and Orbits
M E 57600 Foundation of Mechanical Vibrations
M E 57620 Advanced Concepts in Mechanical Vibrations
M E 57630* Mechanical Feedback Control Systems
M E 57650 Computer-Aided Design
75 hours (including 3 hour/week laboratory), 3 credits
M E 57660* Boundary Element Method
M E 57670 Composite Materials
M E 57680 Nonlinear Dynamic and Chaos
M E 57690 Experimental Methods in Fluid Mechanics and Combustion
M E 57980 Project
M E 58020 Computation and Modeling of Turbulent Flows

*offered infrequently