Electrical and Computer Engineering Department

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Degrees Awarded
M.S. in Electrical Engineering; M.S. in Computer Engineering; Ph.D. in Electrical Engineering; Ph.D. in Computer Engineering

Web Site
http://www.stonybrook.edu/ece

Electrical and Computer Engineering Department

The fields of electrical and computer engineering are in an extraordinary period of growth; new application areas and increased expectations are accelerating due to new technologies and decreased costs. The Electrical and Computer Engineering Department, in the College of Engineering and Applied Sciences, is involved in graduate teaching and research in many of these areas, including communications and signal processing, networking, computer engineering, semiconductor devices and quantum electronics, circuits and VLSI. The department has laboratories devoted to research and advanced teaching in the following areas: computing, engineering design methodology, high-performance computing and networking, parallel and neural processing, machine vision, fiber optic sensors and computer graphics, micro and optoelectronics/VLSI, telerobotics, DNA sequencing, digital signal processing, and communications.

Since Long Island contains one of the highest concentrations of engineering-oriented companies in the country, the department is particularly strongly committed to meeting the needs of local industry. As part of this commitment, most graduate courses are given in the late afternoon or evening, so as to be available to working engineers on Long Island.

The value of this commitment to industry is evidenced by the support received by the department in return; in particular, from Motorola, Lucent Technologies, AT&T, Intel Corporation, and Texas Instruments.

The Department of Electrical and Computer Engineering offers graduate programs leading to the M.S. and Ph.D. degrees. Graduate programs are tailored to the needs of each student to provide a strong analytical background helpful to the study of advanced engineering problems. Ample opportunities exist for students to initiate independent study and to become involved in active research programs, both experimental and theoretical.

Areas of Emphasis in Graduate Study
Areas of emphasis in current research and instruction are: Communications and Signal Processing, Computer Engineering, Semiconductor Devices and Quantum Electronics, Circuits and VLSI.

Specialties that fall under one or more of the above categories include: VLSI, Image Processing, Computer Vision, Integrated Circuit Fabrication, Novel Electronic Devices, Digital Communication, Biomedical Electronics, Computer-Aided Design, Computer Networks, Parallel Processing, Fault-Tolerant Computing, Microprocessors, Robotics, Network Theory, and Optical Signal Processing and Fiber Optic Sensors. Theoretical and experimental programs reflecting these areas are currently underway and students are encouraged to actively participate in these efforts. Outlined below is an overview of the Department's research areas.

Communications and Signal Processing
Subject areas of current interest include mobile, wireless and personal communications; high speed data and computer communication networks; communications traffic; data compression; coding and modulation techniques; inter-connection networks and high speed packet switching; digital communication; detection and estimation; statistical signal processing; spectrum estimation; image analysis and processing; computer vision.

Computer Engineering
The goal of computer engineering in the ECE department is to provide a balance view of hardware and software issues. The expertise in the program include parallel and high performance computer architecture, embedded microprocessor system design, fault tolerant computing, design communications and signal processing, parallel and distributed computing, computer networks, computer vision, artificial neural networks and software engineering.

Semiconductor Devices, Quantum Electronics
The program of courses and of research pertinent to solid-state electronics, electromagnetics and optics ranges from a study of the fundamental electronic processes in solids and gases through a description of the mechanism which yield useful devices to a study of the design simulation, and fabrication of integrated circuits. Program’s scientific interests center on physics, characterization and development of optoelectronic devices and systems. Over the past several years, major efforts were focused on the studies of physics of semiconductor lasers and detectors.
Additionally, the department has a strong experimental effort on the development of coherent optical processors, fiber optic sensors and integrated fiber optics.

**Circuits and VLSI**
The program in the Circuits and VLSI area addresses problems associated to modeling, simulation, design and fabrication of analog, digital, and mixed-signal integrated circuits. Analog and mixed-mode integrated circuit (IC) devices have important applications in many fields including avionics, space technology, and medical technology. The department offers basic and advanced courses covering the following subjects: integrated circuit technology, device modeling, software tools for circuit design and simulation, analog circuit design, VLSI circuits, testing of analog and digital ICs, design automation for analog, digital and mixed-mode circuits, VLSI systems for communications and signal processing.

**Admission requirements of Electrical and Computer Engineering Department**
For admission to graduate study in the Department of Electrical and Computer Engineering, the minimum requirements are:

A. A bachelor’s degree in electrical engineering from an accredited college or university. Outstanding applicants in other technical or scientific fields will be considered, though special make-up coursework over and above the normal requirements for a graduate degree may be required.

B. A minimum grade point average of B in all courses in engineering, mathematics, and science.

C. Official Results of the Graduate Record Examination (GRE) General Test.

D. Acceptance by both the Department of Electrical and Computer Engineering and the Graduate School.

Facilities of Electrical and Computer Engineering Department

The department operates laboratories for both teaching and research:

The **Advanced IC Design & Simulation Laboratory** contains equipment and computing facilities for the design, simulation, and characterization of analog, digital and mixed-signal integrated circuits. The lab is equipped with several SUN workstations and PCs, and assorted electronic measurement equipment.

The **Communications, Signal Processing, Speech, and Vision (CSPV) Laboratory** has several SUN workstations and desktop computers with specialized software for research in telecommunications networks and signal processing. The computers are networked to departmental computing facilities allowing access to shared campus resources and the Internet.

The **Computer-Aided Design Laboratory** provides a network of 386 based workstations. Advanced computer-aided design software for analog and digital systems design is available on these workstations.

The **Computer Vision Laboratory** has state-of-the-art equipment for experimental research in three-dimensional machine vision. The facilities include desktop computers, imaging hardware, and printers.

The **Digital Signal Processing Research Laboratory** is involved in digital signal processing architectures and hardware and software research. The laboratory is presently active in the development of algorithms to be implemented on a variety of signal processing chips.

The **Fluorescence Detection Lab** is involved in the design, development, implementation and testing of various DNA sequencing instruments. Research areas include laser induced fluorescence detection, single photon counting techniques, fast data acquisition and transfer, design and development of analog and digital integrated circuits, signal processing, capillary electrophoresis phenomena and DNA sequencing.

The **Graduate Computing Laboratory** has 12 Windows 2000 Professional based Windows PC’s, equipped with Microsoft Office XP, Microsoft Visual Studio, X-Windows for Unix connectivity, Adobe Acrobat reader, Ghost script and Ghost view. There is an HP LaserJet 5Si/ MX printer. The lab is also equipped with 8 Sun Blade 100 machines. These machines run Sun Solaris 8 operating systems and are connected to the departmental Unix servers. Industry standard packages such as Cadence tools, Synopsys, Hspice and Matlab are available from the application servers.

The **High Performance Computing and Networking Research Laboratory** is equipped to conduct research in the broad area of networking and parallel/distributed computing with emphasis on wireless/mobile networks, cloud computing, data center networks, optical networks, high-speed networks, interconnection networks and multicast communication. The laboratory has 1 Dell PowerEdge 1800 computing server, 8 Dell OptiPlex GX620 MT workstations, 2 Sun Ultra 60 Workstations with dual processors, and 4 Sun Ultra 10 Workstations.

The **Medical Image Processing Laboratory**, located in the medical school, is involved in research in image reconstruction methods and image analysis with applications to medical imaging. It is equipped with a SUN SPARC 10, SPARC 2, HP730 workstations and a full complement of peripherals.

The **Optical Signal Processing and Fiber Optic Sensors Laboratory** research emphasis is on the development and fabrication of novel fiber optic systems for very diverse applications ranging from aerospace to biomedical projects involving the development of new techniques and algorithms. Some of the current research projects include development capillary waveguide based biosensors for detection of pathogens in a marine environment, integrated fiber optic based systems for real time detection of synchronous and asynchronous vibrations in turbomachinery, and single photon based detection schemes for sub-microscopic particle sizing. Equipment includes a fiber optic fusion splicer, fiber polisher, diamond saw, optical microscope, optical spectrometer (visible range), micropositioners, optical scanners, and various laser sources. Additionally, the laboratory has the facilities for designing printed circuits and fabricating optical and electronic sub-systems. Some of the current research projects include development of fiber optic systems for real time process control in adverse environments, integrated fiber optics, fiber optic sensors and coherent optical processing.
The Parallel and Neural Processing Laboratory conducts research in various parallel and neural network applications. Current research projects include Natural Adaptive Critic control, pattern recognitions and Bayesian Neural Networks. It is equipped with Pentium PCs and Synapse3 parallel neural network processing boards.

The Petaflops Design Laboratory is a research facility equipped with two SUN workstations, several PC’s with Linex, and a 16-process Beowulf-type cluster. All computes are connected by Fast 100 Mb/sec Ethernet LAN.

The Semiconductor Optoelectronics Laboratory possesses the infrastructure for wafer processing, testing and sophisticated characterization of optoelectronics devices. Processing facilities are based on a “Class 100” clean room with Darm Suss aligner, Temescal metal film deposition system and other equipment required for modern semiconductor wafer processing. Wafer testing can be performed by low and high temperature probe-stations. Characterization of devices after processing includes electrical, optical and spectral measurements. Electrical and optical measurements can be carried out within a wide frequency range from CW to 22GHz. Semiconductor laser near and far field emission patterns can be studied in a wide spectral range from visible to mid-infrared. Spectral analysis of radiation is performed with high resolution and sensitivity using grating and two Fourier transform spectrometers in combination with state-of-the-art detector systems. Time resolved luminescence experiments are available with ns resolution. The laboratory is equipped with 150fs Nd-glass mode locked laser for optical pumping as well as other pump sources including a high energy Q-switched Nd solid-state laser. New experimental methods of studying semiconductor laser parameters, developed in the Laboratory, include direct heterobarrier leakage current measurements as well as gain, loss and alpha-factor measurements in broad area and single mode lasers.

Requirements for the M.S. Degree in Electrical and Computer Engineering

The M.S. degree in the Department of Electrical and Computer Engineering requires the satisfactory completion of a minimum of 30 graduate credits with a cumulative and departmental grade point average of 3.0 or better. These requirements may be satisfied by either one of the following options:

Any non-ESE course will need prior approval given by the Graduate Program Director before a student can register.

I. Computer Engineering Non-Thesis Option

Admission to the M.S. program in Computer Engineering requires the student to have completed a Bachelor degree in Computer Engineering or Computer Science. Students with a Bachelor degree in Electrical Engineering could also be admitted if they have taken or will take the following courses or their equivalent:

ESE 345 Computer Architecture

ESE 380 Embedded Microprocessor Systems Design I

ESE 333 Real-Time Operating Systems

All non-ESE courses that are not on the pre-approved departmental list that you wish to use toward your degree must receive prior approval from the Graduate Program Director.

The courses listed below can only be used once to satisfy the degree requirements:

Computer Hardware: One course from the following:ESE/CSE 536 Switching and Routing in Parallel and Distributed Systems, ESE 545 Computer Architecture, ESE 565 Parallel Processing Architectures, ESE 566 Hardware-Software Co-Design of Embedded Systems, ESE 580 Microprocessor-Based Systems I, ESE 581 Microprocessor-Based Systems II.

At least three Computer Engineering courses with at least one course from each of the following three sub-areas:


At least three additional regular courses (lecture based courses) offered by the ECE department.

Up to six credits may be from ESE 597, ESE 599, or ESE 698 (only 3 credits of ESE 698 may be used)

ESE 597, ESE 599, ESE 697, ESE 698 and ESE 699 are not counted as regular courses.

Also our Topics course, ESE 670, can be counted only once as a regular course credit toward the M.S. degree. Credits for ESE 597 can only be applied toward the Computer Engineering degree if the following requirements are satisfied:
Prior approval from the Graduate Program Director based on the student submitting a proposal and securing an advisor in the ECE department as well as a contact person at the company involved. Approval will only be granted if it can be demonstrated that the faculty advisor will be kept in close touch with work on the project. To this end, practicum not in the local geographic area will be discouraged.

To obtain satisfactory credit the faculty advisor must verify that a substantial engineering project was undertaken and completed. This will be based on his close contact during the entire period of the project with the student and the contact person and upon reviewing a mandatory written report submitted by the student at the project's completion. The faculty advisor will determine the final grade for the course.

A candidate for the master’s degree may petition to transfer a maximum of 12 graduate credits from another institution towards the master’s degree requirements. Students transferring from non-matriculated status are also limited to a maximum of 12 credits for the master’s degree.

II. Computer Engineering Thesis Option

Students must inform the department in writing at the end of their first semester if they choose the M.S. Thesis Option.

All non-ESE courses that are not on the pre-approved departmental list that you wish to use toward your degree must receive prior approval from the Graduate Program Director.

The M.S. degree with thesis option requires at least 30 graduate credits with a cumulative and departmental grade point average of 3.0 or better. Among these 30 credits, at least six credits of ESE 599, with a maximum of 12 credits total being taken from ESE 597, ESE 599, or ESE 698.

Please note: only 3 credits of ESE 698 may be used in above.

The courses listed below can only be used once to satisfy the degree requirements:

Computer Hardware: One course from the following; ESE/CSE 536 Switching and Routing in Parallel and Distributed Systems, ESE 545 Computer Architecture, ESE 565 Parallel Processing Architectures, ESE 566 Hardware-Software Co-Design of Embedded Systems, ESE 580 Microprocessor-Based Systems I, ESE 581 Microprocessor-Based Systems II.

At least three Computer Engineering courses with at least one course from each of the following three sub-areas:


At least one additional regular course offered by the ECE department.

ESE 597, ESE 599, ESE 697, ESE 698, and ESE 699 are not counted as regular courses.

Also our Topics course, ESE 670, can be counted only once as a regular course credit toward the M.S. degree. Credits for ESE 597 can only be applied toward the Computer Engineering degree if the following requirements are satisfied:

Prior approval from the Graduate Program Director based on the student submitting a proposal and securing an advisor in the ECE department as well as a contact person at the company involved. Approval will only be granted if it can be demonstrated that the faculty advisor will be kept in close touch with work on the project. To this end, practicum not in the local geographic area will be discouraged.

To obtain satisfactory credit the faculty advisor must verify that a substantial engineering project was undertaken and completed. This will be based on his close contact during the entire period of the project with the student and the contact person and upon reviewing a mandatory written report submitted by the student at the project's completion. The faculty advisor will determine the final grade for the course.

A candidate for the master’s degree may petition to transfer a maximum of 12 graduate credits from another institution towards the master’s degree requirements. Students transferring from non-matriculated status are also limited to a maximum of 12 credits for master’s degrees.

Students must satisfactorily complete a thesis.

Requirements for the Ph.D. Degree in Electrical and Computer Engineering

A. Qualifying Examination

There is a major and minor part to the qualifying examination. The written examination is offered once every year, in April. Students must pass one major written examination in two consecutive tries. The two consecutive tries do not need to be in the same area. The minor requirement can be satisfied by taking and passing a second major written examination or by taking three graduate courses in a different area than the major. Previous examinations are available in the departmental office for review, however, students must make their own copies. Please refer to the department’s Graduate Student Guide for additional information on the qualifying examination.

B. Course Requirements
1. A minimum of six regular courses beyond the M.S. degree or 14 regular courses beyond the bachelor’s degree. The choice must have the prior approval of the designated faculty academic advisor. ESE 697 Practicum in Teaching (3 credits) is required to satisfy the teaching requirement. Students must be G-5 status in order to take this course. The courses ESE 597, ESE 598, ESE 599, ESE 698, and ESE 699 are not counted as regular courses. Courses presented under the title ESE 670 Topics in Electrical Sciences that have different subject matters, and are offered as formal lecture courses, are considered different regular courses but may not be counted more than once as a regular course for credit toward the M.S. degree, and not more than twice for all graduate degrees awarded by the Department of Electrical and Computer Engineering.

2. The student must satisfy the stipulations of a plan of study which must be filed with the graduate program committee within six months after the student passes the qualifying examination. The study plan, which will include the six regular courses as required in item 1, will be developed under the aegis of the designated faculty advisor (who may or may not be the eventual thesis advisor). Modification of the study plan may be made by the preliminary examination committee and at any later time by the thesis advisor. An up-to-date plan must always be placed on file with the graduate program committee each time a modification is made.

C. Preliminary Examination
A student must pass the preliminary examination within 3 years of passing the qualifying examination. Both a thesis topic and the thesis background area are emphasized.

D. Advancement to Candidacy
After successfully completing all requirements for the degree other than the dissertation, the student is eligible to be recommended for advancement to candidacy. This status is conferred by the dean of the Graduate School upon recommendation from the chairperson of the department. Students must advance advance to candidacy and pass the Preliminary Exam at least one year prior to the dissertation defense.

E. Dissertation
The most important requirement for the Ph.D. degree is the completion of a dissertation, which must be an original scholarly investigation. The dissertation must represent a significant contribution to the scientific and engineering literature, and its quality must be compatible with the publication standards of appropriate and reputable scholarly journals.

F. Approval and Defense of Dissertation
The dissertation must be orally defended before a dissertation examination committee, and the candidate must obtain approval of the dissertation from this committee. The committee must have a minimum of four members (at least three of whom are faculty members from the department), including the research advisor, at least one person from outside the department, and a committee chair. (Neither the research advisor nor the outside member may serve as the chair). On the basis of the recommendation of this committee, the dean of engineering and applied sciences will recommend acceptance or rejection of the dissertation to the dean of the Graduate School. All requirements for the degree will have been satisfied upon the successful defense of the dissertation.

G. Residency Requirement
The student must complete two consecutive semesters of full-time graduate study. Full-time study is 12 credits per semester until 24 graduate credits have been earned. After 24 graduate credits have been earned, the student may take only nine credits per semester for full-time status.

H. Time Limit
All requirements for the Ph.D. degree must be completed within seven years after completing 24 credits of graduate courses in the department.

Requirements for the Networking & Wireless Communications Certificate (Matriculated students only)

Networking and wireless communications are key technologies in today’s technological world. Networks such as the Internet as well as telephone, cable and wireless networks serve to interconnect people and computers in a ubiquitous and cost effective way. The area of wireless communications in particular has grown rapidly in recent years and has utilized networking technology to be successful. There is a large industrial base involving networking and wireless communications in terms of equipment and software providers, service providers and end users. Moreover this technology has made the average consumer’s life more productive, flexible and enjoyable.

The Stony Brook Certificate Program in Networking and Wireless Communications is designed to give matriculated students validated graduate level instruction in this area of much recent interest. The program can be completed in a reasonable amount of time as it involves only four courses. These are regular Stony Brook graduate level courses taught by Stony Brook faculty. The SUNY approved certificate program can be tailored to the needs of the individual student. Courses used for the certificate program can also be used toward the MS or PhD degree by matriculated students.

Important Note: Admission to the certificate program is limited to students enrolled in either the MS or PhD programs in the Dept. of Electrical & Computer Engineering. Students may receive the certificate if they have no more than 12 graduate credits in the department as of the start of Fall 2015.

To receive the Stony Brook Certificate in Networking and Wireless Communications, a student must complete FOUR required courses as specified below, with at least a B grade in each course.

At least ONE course from the following:
- ESE 505: Wireless Communications
- ESE 506: Wireless Networking

At least ONE course from the following:
- ESE 532: Theory of Digital Communications
• ESE 546: Networking Algorithms and Analysis
• ESE 548: Local and Wide Area Networks

In addition to the above, if needed, courses may be selected from:

• ESE 503: Stochastic Systems
• ESE 504: Performance Evaluation of Communication and Computer Systems
• ESE 522: Fiber Optic Systems
• ESE 528: Communication Systems
• ESE 531: Detection and Estimation Theory
• ESE 535: Information Theory and Reliable Communication
• ESE 536: Switching and Routing in Parallel and Distributed Systems
• ESE 543: Mobile Cloud Computing
• ESE 544: Network Security Engineering
• ESE 547: Digital Signal Processing
• ESE 550: Network Management and Planning
• ESE 552: Interconnection Networks

Students must request the Certificate from Professor Thomas Robertazzi via Email Thomas.Robertazzi@stonybrook.edu once the program is completed.

Faculty of Electrical and Computer Engineering Department

Distinguished Professors
Belenky, Gregory, Doctor of Physical and Mathematical Sciences, 1979, Institute of Physics, Baku, USSR: Design, manufacturing, and characterization of optoelectronic and microelectronic semiconductor devices; physics of semiconductors and semiconductor devices.
Luryi, Serge, Chairperson. Ph.D., 1978, University of Toronto, Canada: High speed solid-state electronic and photonic devices, physics and technology..

Professors
Djuric, Petar M., Ph.D., 1990, University of Rhode Island: Signal analysis, modeling and processing; wireless communications and sensor networks.
Doboli, Alex, Ph.D., 2000, University of Cincinnati: VLSI CAD and design, synthesis and simulation of mixed analog-digital systems, hardware/software co-design of embedded systems, and high-level synthesis of digital circuits.
Hong, Sangjin, Ph.D., 1999, University of Michigan: Low-power VLSI design of multimedia wireless communications and digital signal processing systems, including SOC design methodology and optimization.
Parekh, Jayant P., Ph.D., 1971, Polytechnic Institute of Brooklyn: Microwave acoustics; microwave magnetics; microwave electronics; microcomputer applications.
Robertazzi, Thomas G., 1981, Princeton University: Computer networking; grid computing; performance evaluation; parallel processing; e-commerce technology.
Shamash, Yacov, Dean of the College of Engineering and Applied Sciences. Ph.D., 1973, Imperial College of Science and Technology, England: Control system; robotics.
Short, Kenneth L., Ph.D., 1973, University at Stony Brook: Digital system design; microprocessors; instrumentation.
Subbarao, Murali, Ph.D., 1986, University of Maryland: Computer vision; image processing; pattern recognition.
Yang, Yuanyuan, Graduate Program Director. Ph.D., 1992, Johns Hopkins University: Wireless and mobile networks, cloud computing, data center networks, optical networks, high speed networks, parallel and distributed computing systems, multicast communication, high performance computer architecture, and computer algorithms.

Associate Professors
Bugallo, Monica, Ph.D., 2001, Universidade da Coruna (Spain): Statistical signal processing with the emphasis in the topics of Bayesian analysis, sequential Monte Carlo methods, adaptive filtering, and stochastic optimization.
Dhadwal, Harbans, Ph.D., 1980, University of London, England: Laser light scattering; fiber optics; optical signal processing and instrumentation.
Donetski, Dmitri, Ph.D., 2000, Stony Brook University: Design and technology of optoelectronic devices and systems including photovoltaic and photoconductive detectors, diode lasers and diode laser arrays.

Dorojevets, Mikhail, Ph.D., 1988 Siberian Division of the USSR Academy of Sciences, Novosibirsk: Computer architectures, systems design.

Gindi, Gene, Ph.D., 1981, University of Arizona: Medical image processing; image analysis.

Gorfinkel, Vera, Ph.D., 1980, A.F. Iaffe Physical-Technical Institute, St. Petersburg, Russia: Semiconductor devices, including microwave and optoelectronics, DNA sequencing instrumentation, single photon counting techniques.

Kamoua, Ridha, Ph.D., 1992, University of Michigan: Solid-state devices and circuits; microwave devices and integrated circuits.

Murray, John, Ph.D., 1974, University of Notre Dame: Signal processing; systems theory.

Shterengas, Leon, Ph.D., 2004, Stony Brook University, High power and high speed light emitters, carrier dynamics in nanostructures, molecular beam epitaxy of semiconductor nanostructures.

Stanacevic, Milutin, Ph.D., 2005, Johns Hopkins University: Analog and mixed-signal VLSI integrated circuits and systems; adaptive Microsystems; implantable electronics.


Wang, Xin, Ph.D., 2001, Columbia University, Mobile and ubiquitous computing, wireless communications and networks, grid and distributed computing, advanced applications and services over Internet and wireless networks.

Assistant Professors

Eisaman, Matthew, Ph.D., 2006 Harvard University, Photovoltaic devices, especially light trapping nanostructures for improved solar cell efficiency, and spatial variations at the nanoscale.

Lin, Shan, Ph.D., 2010, University of Virginia, Cyber physical systems, networked information systems, wireless networks, sensing and control systems.

Milder, Peter, Ph.D. 2010, Carnegie –Mellon University, Digital hardware design, generation, and optimization focusing on signal processing, computer vision, and related domains; design for FPGA.

Salman, Emre, Ph.D. 2009, University of Rochester, Nanoscale integrated circuit design, emerging technologies for future electronic systems, highly heterogeneous integrated systems, digital and mixed-signal circuits.

Westerfeld, David, Ph.D. 2005, Stony Brook University, Design and characterization of high-performance mid-infrared semiconductor light sources (LEDs and lasers).


Zhao, Yue, Ph.D., 2011, UCLA, Smart energy systems, renewable energy integration, electricity market, infrastructure security, sensing and signal processing, optimization theory, information theory, communication networks.

Number of teaching, graduate, and research assistants, fall 2014: 64

NOTE: The course descriptions for this program can be found in the corresponding program PDF or at COURSE SEARCH.