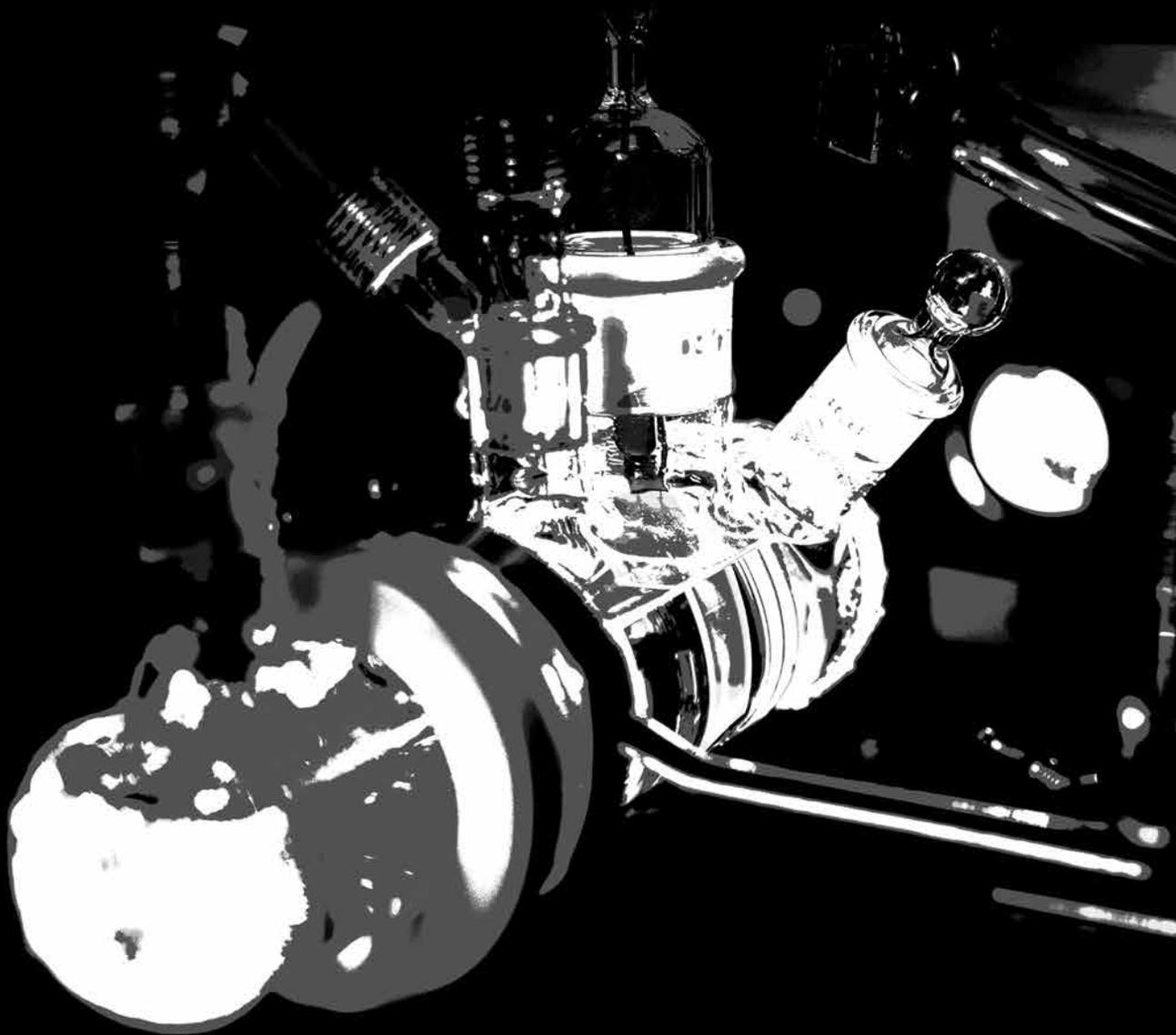




COLUMBIA | ENGINEERING

The Fu Foundation School of Engineering and Applied Science



BULLETIN 2016-2017



Mission

The mission of The Fu Foundation School of Engineering and Applied Science is to expand knowledge and advance technology through research, while educating students to become leaders informed by an engineering foundation. Enriched with the intellectual resources of a global university in the City of New York, we push forward disciplinary frontiers, confront complex issues, and engineer innovative solutions to address the grand challenges of our time. We create a collaborative environment that embraces interdisciplinary thought, integrates entrepreneurship, cultural awareness, and social responsibility, and fosters the translation of ideas into practical innovations.

A MESSAGE FROM THE DEAN



Welcome to Columbia University's Fu Foundation School of Engineering and Applied Science (SEAS). As students here, you are among the very best and brightest of your generation. Together, you are embarking on a course of study that will enable you to become the next generation of leaders, not only in fields of engineering and applied science, but in other disciplines as well, since engineering today is a foundational degree that prepares you for a wealth of pursuits.

You are joining a vibrant and intellectually challenging community, with a long history of scientific and engineering breakthroughs that have impacted our world. From the School's beginning in 1864 through today, the work of faculty, alumni, and students of Columbia Engineering has pushed the frontiers of disciplinary knowledge to create, invent, and innovate devices, materials, and processes to make life better.

Our first dean, Charles Frederick Chandler, serving as president of New York City's Metropolitan Board of Health, crusaded to ensure the purity of food and drugs, the safety of milk, the availability of clean water in the city, and the introduction of building codes. Today, our faculty and students continue to develop innovative solutions to the world's most challenging problems, and with entrepreneurial energy, translate their ideas into real-world impact at an ever faster pace.

You are coming to Columbia Engineering at an extraordinary moment. I believe that Engineering is in a Renaissance. This Renaissance is characterized by great research, great creativity and innovation, and

rapid translation of research and innovations to solutions that have an impact on nearly every aspect of life. It has sparked a new way of thinking, one that crosses disciplinary lines, so that today, engineering is not only informed by other fields, but now is informing other fields.

Our engagements with our world-class sister schools—medicine, public health, architecture, science, business, policy, the social sciences, social work, journalism, even the arts and humanities—enable cross-disciplinary research and education collaborations that will shape the future.

Columbia Engineering is an exciting and stimulating community. I encourage you to take full advantage of the exceptional opportunities for learning and advancement that await you here.

With best wishes for the academic year,

A handwritten signature in black ink that reads "Mary C. Boyce". The signature is written in a cursive, flowing style.

Mary C. Boyce
Dean of Engineering
Morris A. and Alma Schapiro Professor

TABLE OF CONTENTS

About the School and University	1	Faculty and Administration	35	Campus and Student Life	213
HISTORY OF THE SCHOOL	2	Departments and Academic Programs	47	CAMPUS LIFE	214
RESOURCES AND FACILITIES	5	KEY TO COURSE LISTINGS	48	STUDENT SERVICES	219
Undergraduate Studies	9	APPLIED PHYSICS AND APPLIED MATHEMATICS	50	Scholarships, Fellowships, Awards, and Prizes	223
THE UNDERGRADUATE PROGRAMS	10	BIOMEDICAL ENGINEERING	64	Endowed Scholarships and Grants	224
Policy on Degree Requirements	10	CHEMICAL ENGINEERING	76	Endowed Fellowships	228
The First-Year/Sophomore Program	10	CIVIL ENGINEERING AND ENGINEERING MECHANICS	88	Outside Fellowship	230
Study Abroad	14	COMPUTER ENGINEERING PROGRAM	101	Medals and Prizes	230
Combined Plan Programs	16	COMPUTER SCIENCE	106	Residence Hall Scholarships	234
The Junior-Senior Programs	16	EARTH AND ENVIRONMENTAL ENGINEERING	119	University and School Policies, Procedures, and Regulations	235
Programs in Preparation for Other Professions	17	ELECTRICAL ENGINEERING	133	ACADEMIC PROCEDURES AND STANDARDS	236
Joint Programs	18	INDUSTRIAL ENGINEERING AND OPERATIONS RESEARCH	153	ACADEMIC STANDING	240
Undergraduate Admissions	19	MATERIALS SCIENCE AND ENGINEERING PROGRAM	171	POLICY ON CONDUCT AND DISCIPLINE	243
UNDERGRADUATE TUITION, FEES, AND PAYMENTS	20	MECHANICAL ENGINEERING	181	ESSENTIAL POLICIES FOR THE COLUMBIA COMMUNITY	246
FINANCIAL AID FOR UNDERGRADUATE STUDY	22	Undergraduate Minors	197	OFFICIAL UNIVERSITY REGULATIONS	247
Graduate Studies	23	Interdisciplinary Courses and Courses in Other Divisions of the University	203	STUDENT GRIEVANCES, ACADEMIC CONCERNS, AND COMPLAINTS	250
THE GRADUATE PROGRAMS	24	INTERDISCIPLINARY ENGINEERING COURSES	204	Directory of University Resources	253
The Master of Science Degree	24	COURSES IN OTHER DIVISIONS OF THE UNIVERSITY	205	COLUMBIA UNIVERSITY RESOURCE LIST	254
Doctoral Degrees: Eng.Sc.D. and Ph.D.	25	Biological Sciences	205	MAPS	258
Special Nondegree Students	26	Business	205	INDEX	260
COLUMBIA VIDEO NETWORK	27	Chemistry	205	Academic Calendar (see inside back cover)	
GRADUATE ADMISSIONS	28	Earth and Environmental Sciences	206		
GRADUATE TUITION, FEES, AND PAYMENTS	30	Humanities and Social Sciences	208		
FINANCIAL AID FOR GRADUATE STUDY	32	Mathematics	208		
Financing Graduate Education	32	Physics	209		
Instructions for Financial Aid Applicants	32	Statistics	211		
Graduate School Departmental Funding	32				
Alternative Funding Sources	33				
Other Financial Aid—Federal and Private Programs	33				
Veteran's Benefits	33				
Employment	33				
Contact Information	34				

About the School and University



A COLONIAL CHARTER

Since its founding in 1754, as King's College, Columbia University has always been an institution both of and for the City of New York. And with an original charter directing it to teach, among other things, "the arts of Number and Measuring, of Surveying and Navigation, . . . the knowledge of . . . Meteors, Stones, Mines and Minerals, Plants and Animals, and everything useful for the Comfort, the Convenience and Elegance of Life," it has also always been an institution of and for engineers.

EARLY ENGINEERS

An early and influential graduate from the School was John Stevens, Class of 1768. Instrumental in the establishment of U.S. patent law, Stevens procured many patents in early steamboat technology, operated the first steam ferry between New York and New Jersey, received the first railroad charter in the U.S., built a pioneer locomotive, and amassed a fortune, which allowed his sons to found the Stevens Institute of Technology.

THE GILDED AGE

As the city grew, so did the School. King's College was rechartered as Columbia College in 1784, and relocated from the Wall Street area to what is now Midtown in 1857. Students began entering the new School of Mines in 1864. Trained in mining, mineralogy, and engineering, Columbia graduates continued to make their

mark both at home and abroad.

Working around the globe, William Barclay Parsons, Class of 1882, was an engineer on the Chinese railway and the Cape Cod and Panama Canals, and most importantly, for New York, as chief engineer of the city's first subway. Opened in 1904, the subway's electric cars took passengers from City Hall to Brooklyn, the Bronx, and the newly renamed and relocated Columbia University in Morningside Heights.

A MODERN SCHOOL FOR MODERN TIMES

The School of Mines became the School of Mines, Engineering, and Chemistry in 1896, and its professors—now called the Faculty of Engineering and Applied Science—included Michael Idvorsky Pupin, a graduate of the Columbia College Class of 1883. As a professor at Columbia, Pupin did pioneering work in carrier-wave detection and current analysis, with important applications in radio broadcasting; invented the "Pupin coil," which extended the range of long-distance telephones; and taught classes in electromechanics.

An early student of Pupin's was Irving Langmuir. Langmuir, Class of 1903, enjoyed a long career at the General Electric research laboratory, where he invented a gas-filled tungsten lamp; contributed to the development of the radio vacuum tube; extended Gilbert Lewis's work on electron bonding and atomic structure; and researched monolayering and

surface chemistry, which led to a Nobel Prize in chemistry in 1932.

But early work on radio vacuum tubes was not restricted to private industry. Working with Pupin, an engineering student named Edwin Howard Armstrong was conducting experiments with the Audion tube in the basement of Philosophy Hall when he discovered how to amplify radio signals through regenerative circuits. Armstrong, Class of 1913, was stationed in France during the First World War, where he invented the superheterodyne circuit to tune in and detect the frequencies of enemy aircraft ignition systems. After the war, Armstrong improved his method of frequency modulation (FM), and by 1931, had both eliminated the static and improved the fidelity of radio broadcasting forever. The historic significance of Armstrong's contributions was recognized by the U.S. government when the Philosophy Hall laboratory was designated a National Historic Landmark in 2003.

As the United States evolved into a major twentieth-century political power, the University continued to build onto its undergraduate curriculum the broad range of influential graduate and professional schools that define it today. Renamed once again in 1926, the School of Engineering prepared students for careers not only as engineers of nuclear-age technology, but as engineers of the far-reaching political implications of that technology as well.

After receiving a master's degree from the School in 1929, Admiral



Hyman George Rickover served during the Second World War as head of the electrical section of the Navy's Bureau of Ships. A proponent of nuclear sea power, Rickover directed the planning and construction of the world's first nuclear submarine, the 300-foot-long Nautilus, launched in 1954.

TECHNOLOGY AND BEYOND

Today, The Fu Foundation School of Engineering and Applied Science, as it was named in 1997, continues to provide leadership for scientific and educational advances. Even Joseph Engelberger, Class of 1946, the father of modern robotics, could not have anticipated the revolutionary speed with which cumbersome and expensive "big science" computers would shrink to the size of a wallet.

No one could have imagined the explosive growth of technology and its interdisciplinary impact. The Engineering School is in a unique position to take advantage of the research facilities and talents housed at Columbia to form relationships among and between other schools

and departments within the University. The School's newest department, Biomedical Engineering, with close ties to the Medical School, is but one example. Interdisciplinary centers are the norm, with cross-disciplinary research going on in biomedical imaging, environmental chemistry, materials science, medical digital libraries, nanotechnology, digital, and new media technologies. The School and its departments have links to the Departments of Physics, Chemistry, Earth Science, and Mathematics, as well as the College of Physicians and Surgeons, the Graduate School of Journalism, Lamont-Doherty Earth Observatory, The Earth Institute, Teachers College, Columbia Business School, and the Graduate School of Architecture, Planning and Preservation. The transforming gift of The Fu Foundation has catapulted the School into the forefront of collaborative research and teaching and has given students the opportunity to work with prize-winning academicians, including Nobel laureates, from many disciplines.

NEW RESEARCH FRONTIERS

Columbia's technology transfer office, Columbia Technology Ventures, works with faculty inventors to commercialize ideas and brings in millions in licensing revenue annually. Columbia Engineering faculty have been instrumental in developing some of the most successful inventions in consumer electronics, as well as establishing many of the widely accepted global standards for storage and transmission of high-quality audio and video data. Perhaps the most famous of these is the MPEG-2 data compression standard, which is embedded in millions of DVDs and DVD players. With Columbia Engineering faculty continuing to play a key role in current and evolving information technology, Columbia is the only university actively participating in a broad range of standards-based patent pools, including AVC (Advanced Video Coding), the world standard for audio/video compression that is now one of the most commonly used HD formats and most commonly used in streaming media; and ATSC, a

standard developed by the Advanced Television Systems Committee for digital television transmission that is now the U.S. standard for recording and retrieval of data and HD audio-visual media. In addition to the standards, Columbia Engineering faculty have patents in areas as diverse as modular cameras, waste management, a search engine that matches facial features, and even methods to combat virtual reality sickness.

Increasingly, the inventions emerging from Columbia Engineering are developed in collaboration with biomedical and other researchers, expanding the potential applications for their important work. Programs such as the Columbia-Coulter Translational Research Partnership, PowerBridgeNY, the NYC Media Lab Combine program, and the Integrated Photonics Manufacturing Innovation Hub in Rochester, NY, are strengthening interdisciplinary capacity and fostering an entrepreneurial and inventive energy within the School. Some of these programs have helped prepare ideas for commercialization, including robotics for revolutionizing personal medicine in the physical rehabilitation space, a minimally-invasive glucose sensor using MEMS, and a high-density, low-noise bioelectronics platform using CMOS electronics.

ENTREPRENEURSHIP

Another exciting area at Columbia Engineering is entrepreneurship. In 2016, the School's faculty and students generated 120 inventions, almost 40 licenses and options, and four startup companies in all kinds of fields, from biomedical to cleantech to high-tech.

Throughout the academic year, the School hosts many activities and networking events to support its active startup community, including

the Columbia Engineering Fast Pitch Competition, Columbia Venture Competition, Design Challenges, Hackathons, and the Ignition Grants program, which funds ventures started by current students.

The School's Translational Fellows Program (TFP) supports 20 percent of the salary of selected SEAS postdoctoral researchers and research scientists for one year, providing them with the opportunity to pursue commercialization of a technology that originated in their research work here at the Engineering School. Another exciting way the School fosters entrepreneurship is with its Coulter Program. A major goal of the program is to educate researchers, clinicians, and students about the many aspects involved in commercializing biomedical innovation.

Entrepreneurship remains an important central educational theme at Columbia Engineering. The School promotes engineering innovation and engaged entrepreneurship through a range of programs and offers a 15-credit, interdisciplinary minor in entrepreneurship made up of both Engineering and Business School courses. The School also provides a four-year entrepreneurship experience for all interested Columbia Engineering students, regardless of major.

And for alumni, entrepreneurial support continues. The Columbia Startup Lab, a co-working facility located in SoHo, provides subsidized space for 71 Columbia alumni entrepreneurs to house and nurture their fledgling ventures. The Lab is the result of a unique partnership between the deans of Columbia College and the Schools of Business, Engineering, Law, and International and Public Affairs. Columbia Engineering has seats for recent graduates (five years since graduation).

A FORWARD-LOOKING TRADITION

But, for all its change, there is still a continuous educational thread that remains the same. Columbia Engineering still remains an institution of manageable size within a great university. Committed to the educational philosophy that a broad, rigorous exposure to the liberal arts provides the surest chart with which an engineer can navigate the future, all undergraduates must complete a modified but equally rigorous version of Columbia College's celebrated Core Curriculum. It is these selected courses in contemporary civilization in the West and other global cultures that best prepare a student for advanced course work; a wide range of eventual professions; and a continuing, life-long pursuit of knowledge, understanding, and social perspective. It is also these Core courses that most closely tie today's student to the alumni of centuries past. Through a shared exposure to the nontechnical areas, all Columbia Engineering students—past, present, and future—gain the humanistic tools needed to build lives not solely as technical innovators, but also as social and political ones as well.

A COLLEGE WITHIN THE UNIVERSITY

A unique educational opportunity, The Fu Foundation School of Engineering and Applied Science at Columbia University offers programs to both undergraduate and graduate students who undertake a course of study leading to the bachelor's, master's, or doctoral degree in engineering and applied science. Combining the advantages of a small college with the extensive resources of a major research university, students at Columbia Engineering pursue their academic interests under the guidance of outstanding senior faculty members who teach both undergraduate and graduate level courses. Encouraged by the faculty to undertake research at all levels, students at the School receive the kind of personal attention that only Columbia's exceptionally high faculty-student ratio affords.

THE NEW YORK ADVANTAGE

Besides the faculty, the single greatest facility at a Columbia student's disposal is without doubt the City of New York. Within easy reach by walking, bus, subway, or taxi, New York's broad range of social, cultural, and business communities offer an unparalleled opportunity for students to expand their horizons or deepen their understanding of almost any human endeavor imaginable. With art from small Chelsea galleries to major museums; music from Harlem jazz clubs to the Metropolitan Opera; theater from performance art in the

East Village to musicals on Broadway; food from around the world, from South America to Asia, from Colombia arepas to Cantonese dim sum; and sports from baseball and basketball, to tennis and hockey, New York is the crossroads of the world.

New York is a major player in high-tech research and development, where Fortune 500 companies traded on Wall Street seek partnerships with high-tech startups in Tribeca and Brooklyn. As part of the research community themselves, Columbia students have exceptional opportunities for contact with industry both on and off campus. Senior representatives of these companies often visit Columbia to lecture as adjunct faculty members or as guest speakers, and undergraduate and graduate students frequently undertake research or internships with these and other companies, oftentimes leading to offers of full-time employment after graduation.

In addition to its ties to private industry, Columbia also has a historically close relationship with the public sector of New York, stretching back to the eighteenth century. No other city in the world offers as many impressive examples of the built environment—the world's most famous collection of skyscrapers, long-span bridges, road and railroad tunnels, and one of the world's largest subway and water supply systems. Involved in all aspects of the city's growth and capital improvements over the years, Columbia engineers have been responsible for the design, analysis, and maintenance of New York's

enormous infrastructure of municipal services and communications links, as well as its great buildings, bridges, tunnels, and monuments.

THE UNIVERSITY AT LARGE

Columbia University occupies two major campuses, as well as additional special-purpose facilities throughout the area. Besides the main campus located on the Upper West Side in Morningside Heights, further uptown in Washington Heights is the Columbia University Medical Center (CUMC), which includes Columbia's College of Physicians and Surgeons, the Mailman School of Public Health, the New York State Psychiatric Institute, College of Dental Medicine, and School of Nursing. Columbia Medical Center is the world's first academic medical center, and opened in 1928 when Columbia's health-related schools and Presbyterian Hospital (which has since merged with New York Hospital to become NewYork-Presbyterian Hospital) moved to the Washington Heights location. Columbia Engineering's Biomedical Engineering Department has offices on both the Morningside campus and CUMC.

Beyond its schools and programs, the measure of Columbia's true breadth and depth must take into account its seventy-odd internationally recognized centers and institutions for specialized research, which study everything from human rights to molecular recognition, as well as the close affiliations it holds with Teachers College, Barnard College, the Juilliard

School, and both the Jewish and Union Theological Seminaries. Columbia also maintains major off-campus facilities such as the Lamont-Doherty Earth Observatory in Palisades, NY, and the Nevis Laboratories in Irvington, NY. Involved in many cooperative ventures, Columbia also conducts ongoing research at such facilities as Brookhaven National Laboratory in Upton, NY, and the NASA Goddard Institute for Space Studies located just off the Morningside campus.

THE MORNINGSIDE HEIGHTS CAMPUS

The Fu Foundation School of Engineering and Applied Science is located on Columbia's Morningside campus. One of the handsomest urban institutions in the country, the 13.1 million gross square feet (gsf) of the Morningside campus comprise more than 200 buildings of housing; off-campus apartments and commercial buildings; recreation and research facilities; centers for the humanities and social and pure sciences; and professional schools in architecture, business, the fine arts, journalism, law, and many other fields.

MANHATTANVILLE CAMPUS

From Broadway and 125th Street West to a revitalized Hudson River waterfront, Columbia's 17-acre Manhattanville campus will be a welcoming environment of publicly accessible open space, tree-lined streets, neighborhood-friendly retail and innovative academic buildings that invite community engagement. The first new buildings will be completed during the 2016–2017 academic year. New buildings now under construction will house cutting-edge research and teaching in brain science, art galleries and performance spaces, and space for active community engagement. The Jerome L. Greene Science Center, for one, houses the Mortimer B. Zuckerman Mind Brain Behavior Institute, which includes several members of the SEAS faculty. The Institute serves as a thriving hub where faculty and students from across Columbia, scholars from around the world, and members of

the local community come together in the search for new insights about ourselves, exploring the complexities of the human mind and brain.

THE FU FOUNDATION SCHOOL OF ENGINEERING AND APPLIED SCIENCE

The Fu Foundation School of Engineering and Applied Science occupies four laboratory and classroom buildings at the north end of the campus, including the Northwest Corner Science and Engineering Building, an interdisciplinary teaching and research building on the Morningside campus. It was designed by the world-renowned architect Jose Rafael Moneo to serve as a physical and intellectual bridge, linking laboratories and maximizing the ready sharing and exchange of ideas, resources, and information. With its beehive-like setting, the new building is already enhancing existing collaborations and stimulating new ones, enabling researchers across the University to work together to create new areas of knowledge, in fields where the biological, physical, and digital worlds fuse. This pandisciplinary frontier is the nexus at which engineering and applied scientific advances will provide innovative solutions to some of modern society's most challenging problems in a wide range of sectors, from health to cybersecurity, from smart infrastructure to the environment.

Offering multiple programs of study, with facilities specifically designed and equipped to meet the laboratory and research needs of both undergraduate and graduate students, the School is the site of an almost overwhelming array of basic and advanced research installations, such as the Columbia Genome Center and the Columbia Nano Initiative, newly established to serve as the hub for multidisciplinary and collaborative research programs in nanoscale science and engineering. Shared facilities and equipment to support nano research at the Engineering School include a state-of-the-art clean room in the Schapiro Center for Engineering and Physical Science Research (CEPSR) and a

recently constructed Transmission Electron Microscope (TEM) Laboratory on the first floor of Havemeyer.

In addition to this group of advanced research opportunities and one that stems from an interdisciplinary framework is the Columbia Data Science Institute, hosted by Columbia Engineering. Founded in 2012 with a grant from New York City, the Data Science Institute spans nine schools at Columbia, including Journalism, the Graduate School of Arts and Sciences, and Columbia University Medical Center. The mission of the Data Science Institute is to train data science innovators and develop ideas for the social good.

Details about specific programs' laboratories and equipment can be found in the sections describing those programs.

Columbia Engineering Computing Facilities

The Botwinick Multimedia Learning Laboratory at Columbia University has redefined the way engineers are educated here.

Designed with both education and interaction in mind, the lab provides students and instructors with 40 Apple Mac Pro workstations connected to central servers and a network-based RAID storage array, a full set of professional-grade engineering software tools, and a collaborative classroom learning environment to help them engage in real-world interactions with community clients, Engineering faculty, and professional practitioners. It is utilized in some of the School's introductory first-year engineering projects, as well as advanced classes in modeling and animation, technology and society, and entrepreneurship.

The Makerspace

Columbia Engineering's Makerspace provides students a dedicated place at the School to collaborate, learn, explore, experiment, and create prototypes. Students can utilize the space to work on a variety of innovative projects, including independent or group design projects, product development, and new venture plans. Located on the twelfth

floor of the Mudd Building, this facility fosters student creativity by bringing together the workspace and tools for computer-aided design, physical prototyping, fabric arts, woodworking, electronics, and software.

Carleton Commons

Located on the fourth floor (campus level) of the Mudd Building, the newly renovated Carleton Commons and Blue Java Café comprise 3,200 square feet with seating for 160 and areas for casual meetings, individual and group work, and quiet study. Carleton Commons gives students a dedicated and comfortable space to gather, relax between classes, or meet and work with one another on problem sets or projects. The new design also enables flexible and reconfigurable use of the space for larger gatherings and special events.

CENTRAL COMPUTING RESOURCES

Columbia University Information Technology (CUIT)

Help Desk Support Center
202 Philosophy Hall
Monday–Friday: 10:00 a.m.–6:00 p.m.

Phone: 212-854-1919
Monday–Thursday: 8:00 a.m.–11:00 p.m.
Friday: 8:00 a.m.–7:00 p.m.
Saturday: 10:00 a.m.–6:00 p.m.
Sunday: 3:00 p.m.–11:00 p.m.
E-mail: askcuit@columbia.edu
cuit.columbia.edu/support

CUIT provides Columbia University students, faculty, and staff with myriad central computing and communications services, including Columbia's wireless and high-speed campus Ethernet network, available to all students in residence hall rooms. CUIT also manages an array of computer labs, terminal clusters, ColumbiaNet kiosk stations, electronic classrooms, and provides a variety of technical support services via the CUIT Helpdesk.

CUIT services include the following:

- *E-mail accounts:* CUIT provides a web-based program for accessing Columbia e-mail. It provides a secure

and convenient way to send and receive mail from anywhere, using any web browser.

- *Computer account IDs* provide access to Columbia's secure online information resources, campus computer labs, and printing on CUIT printers. All Columbia students, faculty, and staff are assigned an ID account (called University Network ID or UNI).
- *Columbia's website* provides access to hundreds of online services and resources, including extensive academic, scholarly, and administrative resources, myriad library catalogs and references, the Directory of Classes, registration information, campus publications, and events listings.
- *Technical support* is available through the CUIT Help Desk, which provides technical assistance to students on the Morningside campus online, by phone, or in person. (See beginning of this section for hours and contact information.)
- *Canvas* is the University course management system. It allows instructors to easily develop and maintain course websites, distribute class materials, link to online reserves, administer quizzes and tests, communicate with students, and promote online discussions.
- *Electronic classrooms* are equipped with multimedia capabilities such as computer and projection systems, DVD and CD-ROM players, VCRs, and audio systems.
- *Public computer kiosks* are available in various locations around the Morningside campus for accessing Columbia's web resources and e-mail.
- *Computer labs and clusters* provide students, faculty, and researchers with access to a range of software. Some locations have consultants to provide lab help.
- *Printing facilities* are available throughout the Morningside campus and Barnard College. These high-speed, high-volume printers are located in CUIT computer labs, libraries, residence halls, and other computer clusters and electronic classrooms.
- *Computer security* is extremely important at Columbia and CUIT

provides several resources online, including links to download antivirus and anti-spyware software. The site also provides information on how to protect your system, data, and privacy when working online.

- *Electronic Data Service*, run jointly by CUIT and the Libraries, provides computing support for researchers with data-intensive applications, including statistical software, and finding and selecting appropriate data.
- *Telephone and cable TV service* is available to students living in University residence halls.

COLUMBIA UNIVERSITY LIBRARIES

Phone: 212-851-2950
E-mail: ref-sci@columbia.edu
library.columbia.edu

Columbia University Libraries (CUL) is one of the top five academic research library systems in North America. The collections include 11.9 million volumes, 168,000 current serial subscriptions, as well as extensive electronic resources, manuscripts, rare books, microforms, maps, graphic and audio-visual materials. The services and collections are organized into 19 libraries and various academic technology centers. The Libraries employ more than 550 professional and support staff. The website of the Libraries is the gateway to its services and resources.

The Science and Engineering Library, located in 401 Northwest Corner Building, focuses on research support for the fields of astronomy, biology, chemistry, engineering, physics, and psychology, as well as providing a collaborative environment supporting rapidly expanding interdisciplinary science and engineering research. The Science and Engineering Library is home to the Digital Science Center, where high-end computers are especially equipped with software and hardware to support teaching, learning, research, and innovation in the science and engineering disciplines. Group study, individual carrels, and staff consultation spaces along with printing

and scanning facilities are included in this library, which offers spectacular views of the Columbia campus and Morningside Heights.

Online, CUL provides access to extensive collections of electronic journals, ebooks, handbooks, standards, patents, and society publications. Databases such as Compendex, INSPEC, Scopus, and Web of Science help patrons to pinpoint relevant engineering and science research.

CENTER FOR CAREER EDUCATION

East Campus, Lower Level
Mailing: 2960 Broadway, MC 5727
Delivery: 70–74 Morningside Drive
New York, NY 10027
Phone: 212-854-5609
Fax: 212-854-5640
E-mail: careereducation@columbia.edu
careereducation.columbia.edu

The Columbia University Center for Career Education (CCE) helps students and alumni develop the key competencies to make informed decisions and take the necessary steps to achieve their career goals. CCE establishes connections and facilitates interaction among undergraduate students, graduate students, alumni, and employers to generate opportunities that help students pursue their personal and professional career objectives.

We encourage students and alumni to (1) visit us at the Career Center; (2) register for Columbia's job and internship database, LionSHARE; and (3) review our website to access a wide range of services and resources. CCE develops relationships with employers to connect students with internships, full-time, part-time, and temporary on- and off-campus employment opportunities throughout the year. In addition, CCE provides career development opportunities for students beginning in their first year at Columbia, offering externships, internships, résumé and interviewing preparation, site visits to employers, professionals in residence, career fairs, alumni-student networking events, and individual counseling.

Highlights among career fairs include the Engineering Career Fair in the fall and the Startup Career Fair in the spring. Additionally, CCE partners with Columbia Engineering on specialized networking events, employer information sessions, and workshops tailored to department and student club needs.

CCE has developed formal externship and internship and professional development programs in partnership with alumni and employers, including the Science Technology Engineering Program, the Virtual Internship Program, the Startup Internship Program, Columbia Arts Experience, and the Kenneth Cole Community Action Program. Also through our Columbia Experience Overseas program, we offer summer internships in London, Hong Kong, Beijing, Shanghai, Singapore, Mumbai, Seoul, and Amman. Alumni mentors are assigned to all students participating in these formal internship programs. CCE also administers the Work Exemption Program and the Columbia Engineering Internship Fund to help students undertake internships. Some of these programs are open to all students while others are open only to undergraduate students. We invite you to connect with CCE to learn about eligibility requirements.

CCE also maintains a dossier service, managed by Interfolio, for graduate students and alumni. A dossier consists of letters of reference and other credentials that speak to a candidate's scholarship, research interests, and teaching experience. It is typically used in applying for teaching positions at either the secondary school or the college level and for graduate/ professional school and fellowship applications. Undergraduate students or alumni with undergraduate degrees from Columbia Engineering work with the James H. and Christine Turk Berick Center for Student Advising for dossier management.

We welcome your visit to the Center for Career Education in person at East Campus or via our website at careereducation.columbia.edu to learn more about our programs and resources.

THE INTERNATIONAL STUDENTS AND SCHOLARS OFFICE

International House North
524 Riverside Drive, Suite 200
Mailing: 2960 Broadway, MC 5724
New York, NY 10027

Phone: 212-854-3587
Fax: 212-851-1235
E-mail: isso@columbia.edu
columbia.edu/cu/isso

Columbia University, continuing its tradition as a preeminent world center of learning, welcomes more than 12,000 students, interns, researchers, professors and accompanying family members from over 150 countries.

The ISSO serves the immigration- and documentation-related needs of students and scholars at the University. They issue Certificates of Eligibility for F and J visa status (I-20/DS-2019), provide travel signatures, employment information and applications, documentation needed for Social Security number applications, and other matters relating to their immigration status at Columbia.

The ISSO monitors regulations affecting relevant immigration classifications and broadcasts timely alerts and updates to students through the ISSOnews listserv and targeted messages.

Throughout the academic year they offer an annual series of informational workshops on employment in student status and on employment-based immigration status options after student status, presented by nationally recognized attorney. During the U.S. "tax season," February to April, they provide free access to tax preparation software to assist students in compliance with their US tax-filing obligation.

The ISSO provides an immigration information session to new students as part of their school or department's new student orientation program.

Undergraduate Studies



The undergraduate programs at Columbia Engineering not only are academically exciting and technically innovative but also lead into a wide range of career paths for the educated citizen of the twenty-first century. Whether you want to become a professional engineer, work in industry or government, or plan to pursue a career in the physical and social sciences, medicine, law, business, or education, Columbia Engineering will provide you with an unparalleled education.

The School firmly believes that students gain the most when engineering is brought up front, early in the four-year curriculum. Therefore, each first-year student takes the Art of Engineering, which addresses the fundamental concepts of math and science in an engineering context, as well as nontechnical issues in professional engineering practice such as ethics and project management. Students in the Art of Engineering choose a half-semester, hands-on project in one of the School's nine undergraduate engineering disciplines, followed by a half-semester general project that changes each year. Depending on the project chosen, students will solder, 3D print, laser cut, simulate, design websites, and much more. These skills are further developed as students progress toward their senior year projects. Since the fall of 2014, Columbia Engineering students have been able to utilize the School's brand new Makerspace, a collaborative environment where students can learn, explore, experiment, and create prototypes.

While pursuing their own interests,

undergraduate students are encouraged to participate in a broad range of ongoing faculty research projects encompassed by the Student Research Involvement Program (SRIP). An annual publication describes faculty projects in which students may participate, lists necessary qualifications, and details whether the student's participation will be voluntary, for academic credit, or for monetary compensation. Students can apply for available research positions in Columbia Labs through the SRIP website at portal.seas.columbia.edu/research/student.php/position.

In addition to in-depth exploration of engineering and applied science, Columbia Engineering undergraduates explore the humanities and social sciences with Columbia College students through intellectually challenging Core Curriculum courses taught by the Faculty of Arts and Sciences. These courses in art, literature, music, major cultures, and economics, among others, provide students with a broad, intellectually disciplined, cultural perspective on the times they live in and the work they do.

POLICY ON DEGREE REQUIREMENTS

The Committee on Instruction and faculty of The Fu Foundation School of Engineering and Applied Science review degree requirements and curricula matters each year, and the bulletin reflects these faculty recommendations and curricular changes in its yearly reprinting. School

policy requires students to fulfill all general degree requirements as stated in the bulletin of the first year of their matriculation into the School. Students declare their major during the first semester of their sophomore year. Requirements for the major or minor are in accordance with the bulletin during the year in which the student declares the major or minor.

THE FIRST-YEAR/SOPHOMORE PROGRAM

Students entering Columbia Engineering are encouraged to consider the wide range of possibilities open to them, both academically and professionally. To this end, the first and second years of the four-year undergraduate program comprise approximately 66 semester points of credit that expose students to a cross-fertilization of ideas from different disciplines within the University. The sequence of study proceeds from an engagement with engineering and scientific fundamentals, along with humanities and social sciences, toward an increasingly focused training in the third and fourth years designed to give students mastery of certain principles and arts central to engineering and applied science.

Liberal Arts Core for Columbia Engineering Students: 27-Point Nontechnical Requirement

This requirement provides a broad liberal arts component that enhances the Engineering professional curriculum to help students meet the challenges

of the twenty-first century. Our students are destined to be leaders in their professions and will require sophisticated communication, planning, and management skills. The Committee on Instruction established the School's nontechnical requirement so that students would learn perspectives and principles of the humanities and social sciences as part of a well-rounded and multiperspective education. Through discussion, debate, and writing, students improve their abilities to engage in ethical, analytic, discursive, and imaginative thinking that will prove indispensable later in life.

- Engineering students must take 16 to 18 points of credit of required courses in list A and 9 to 11 elective points chosen from the approved courses in list B. The total combined number of nontechnical points (from lists A and B, below) must add up to at least 27. Neither list can be modified by advising deans or faculty advisers.
- Advanced Placement (AP) credit in appropriate subject areas can be applied toward the 9-point elective nontechnical requirement.

A. Required Nontechnical Courses (16–18 points of credit)
These courses must be taken at Columbia.

1. ENGL UN1010: University writing (3 points)
2. One of the following two-semester sequences: HUMA CC1001-CC1002: Masterpieces of Western literature and philosophy (All students registering for this course should be prepared to discuss books 1–12 of the Iliad on the first day of class) or COCI CC1101-CC1102: Introduction to contemporary civilization in the West or Global Core: Any 2 courses from approved list (6–8 points)
If electing Global Core, students must take two courses from the List of Approved Courses (college.columbia.edu/sites/default/files/global_core.pdf) for a letter grade.
3. One of the following two courses: HUMA UN1121: Masterpieces of Western art, or HUMA UN1123: Masterpieces of Western music (3 points)

4. ECON UN1105: Principles of economics. (This course can be satisfied through Advanced Placement; see the Advanced Placement chart on page 14.) Note: Engineering students may not take BC1003: Introduction to economic reasoning as a substitute for ECON UN1105. (4 points)

B. Elective Nontechnical Courses (9–11 points of credit)

The following course listing by department specifies the Columbia College, Barnard, or Columbia Engineering courses that either fulfill or do not fulfill the nontechnical requirement.

(Professional, workshop, lab, project, scientific, studio, music instruction, and master's-level professional courses do not satisfy the 27-point nontechnical requirement.)

AFRICAN-AMERICAN STUDIES: All courses

AMERICAN STUDIES: All courses

ANCIENT STUDIES: All courses

ANTHROPOLOGY: All courses in sociocultural anthropology

All courses in archaeology except field work
No courses in biological/physical anthropology [UN1010, UN1011, UN3204, UN3940, GU4147-GU4148, GU4200, GU4700]

ARCHITECTURE: No courses

ART HISTORY AND ARCHEOLOGY:
All courses

ASIAN AMERICAN STUDIES: All courses

ASTRONOMY: No courses

BIOLOGICAL SCIENCES: No courses

BUSINESS: No courses

CHEMISTRY: No courses

CLASSICS: All courses

COLLOQUIA: All courses

COMPARATIVE ETHNIC STUDIES: All courses

COMPARATIVE LITERATURE AND SOCIETY: All courses

COMPUTER SCIENCE: No courses

CREATIVE WRITING: All courses
(This is an exception to the workshop rule.)

DANCE: All courses except performance classes

DRAMA AND THEATRE ARTS: All courses except workshops, rehearsal, or performance classes, THTR BC2120 Technical production, THTR BC3135 Set design, and THTR BC3134 Lighting design

EARTH AND ENVIRONMENTAL SCIENCES:
No courses

EAST ASIAN LANGUAGES AND CULTURE:
All courses

ECOLOGY, EVOLUTION, AND ENVIRONMENTAL BIOLOGY: No courses except EEGB GU4321 or GU4700

ECONOMICS: All courses except UN3025 Financial economics
UN3211 Intermediate microeconomics
UN3213 Intermediate macroeconomics
UN3412 Introduction to econometrics
GU4020 Economics of uncertainty and information

GU4211 Advanced microeconomics
GU4213 Advanced macroeconomics
GU4251 Industrial organization
GU4280 Corporate finance
GU4412 Advanced econometrics
GU4415 Game theory

GU4911 Seminar in microeconomics
GU4913 Seminar in macroeconomics
GU4918 Seminar in econometrics
BC1003 Introduction to economic reasoning (equivalent to ECON UN1105)
BC1007 Mathematical methods for economics

BC2411 Statistics for economics
BC3014 Entrepreneurship
BC3018 Econometrics
BC3033 Intermediate macroeconomic theory
BC3035 Intermediate microeconomic theory
BC3038 International money and finance

EDUCATION: All courses

ENGINEERING: Only BMEN E4010 Ethics for biomedical engineers
EEHS E3900 History of telecommunications

ENGLISH AND COMPARATIVE LITERATURE: All courses

FILM STUDIES: All courses except lab courses, and UN3920 Senior seminar in screenwriting
UN2400 The film medium: script analysis

FRENCH AND ROMANCE PHILOLOGY:
All courses

GERMANIC LANGUAGES: All courses

GREEK: All courses

HISTORY: A II courses

HISTORY AND PHILOSOPHY OF SCIENCE:

All courses

HUMAN RIGHTS: All courses**ITALIAN:** All courses**JAZZ STUDIES:** All courses**LATIN:** All courses**LATINO STUDIES:** All courses**LINGUISTICS:** All courses except CLLN GU4202**MATHEMATICS:** No courses**MEDIEVAL AND RENAISSANCE STUDIES:** All courses**MIDDLE EASTERN AND ASIAN LANGUAGE AND CULTURES:** All courses**MUSIC:** All courses except performance courses, instrument instruction courses, and workshops**PHILOSOPHY:** All courses except

UN1401 Introduction to logic

UN3411 Symbolic logic

GU4137 Nonclassical logics

GU4431 Introduction to set theory

GU4424 Modal logic

CSPH GU4801 Mathematical logic I

CSPH GU4802 Incompleteness results in logic

Courses in logic

PHYSICAL EDUCATION: No courses**PHYSICS:** No courses**POLITICAL SCIENCE:** All courses except

UN3220 Logic of collective choice

UN3704 Data analysis and statistics for political science research

UN3720 Scope and methods

GU4730 Game theory and political theory

GU4732 Research topics in game theory

GU4791 Advanced topics in quantitative research

GU4792 Advanced topics in quantitative research

GU4700 Math methods for political science

GU4765 Design and analysis of sample surveys

GU4768 Experimental research: design, analysis and interpretation

GU4710 Principles of quantitative political research

GU4711 Analysis of political data

GU4712 Multivariate political analysis

PSYCHOLOGY: Only

UN1001 The science of psychology

UN2235 Thinking and decision making

UN2240 Human communication

UN2280 Introduction to developmental psychology

UN2610 Introduction to personality

UN2620 Abnormal behavior

UN2630 Social psychology

UN2640 Introduction to social cognition

UN2680 Social and personality development

UN3615 Children at risk

UN3630 Seminar in social cognition

RELIGION: All courses**SLAVIC LANGUAGES:** All courses**SOCIOLOGY:** All courses except

SOC1 UN3020 Social Statistics

SPANISH AND PORTUGUESE: All courses**SPEECH:** No courses**STATISTICS:** No courses**SUSTAINABLE DEVELOPMENT:** No courses**URBAN STUDIES:** All courses**VISUAL ARTS:** No more than one course, which must be at the 3000-level or higher (This is an exception to the workshop rule.)**WOMEN AND GENDER STUDIES:** All courses**Music Instruction Courses**

Music instruction and performance courses do not count toward the 128 points of credit required for a B.S. degree. Please note that this includes courses taken at Teachers College, Columbia College, and the School of the Arts.

Visual Arts Courses

Students are allowed to take courses in the Visual Arts Department for general credit to be applied toward the B.S. degree. However, no more than one visual arts course, which must be taken at the 3000 level or higher, may count toward the nontechnical elective requirement. This 3000 course is an exception to the rule that no workshop classes can fulfill the nontech elective requirement.

Technical Course Requirements

The prescribed First Year–Sophomore Program curriculum requires students to complete a program of technical course work introducing them to five major areas of technical inquiry: engineering, mathematics, physics, chemistry, and computer science.

All first-year Engineering undergraduate students take ENGI E1102: The art of engineering (4 points). In this course, students see how their high school science and math knowledge can be applied in an engineering context to solve real-world problems through classroom presentations and participation in an in-depth, hands-on project. Along with the course, guest lecturers discuss social implications of technology, entrepreneurship, project management, and other important nontechnical issues affecting the practicing engineer.

While students need not officially commit to a particular branch of engineering until the third semester, most programs recommend, and in some cases may require, that particular courses be taken earlier for maximum efficiency in program planning. For information concerning these requirements, students should turn to the individual program sections in this bulletin.

Professional-Level Courses

The courses listed below may be taken by first- and second-year students. Some departments require one of these courses; please consult with departmental charts for more information.

The courses stipulate minimal prerequisites. Each course serves as an introduction to the area of study in addition to teaching the subject matter. Each course is taught by regular department faculty and thus provides a double introduction to both subject area and faculty.

The courses are:

APAM E1601y Introduction to computational mathematics and physics

Not offered in 2016–2017.

Mathematics and physics problems solved by using computers. Topics include elementary interpolation of functions, solution of nonlinear algebraic equations, curve-fitting and hypothesis testing, wave propagation, fluid motion, gravitational and celestial mechanics, and chaotic dynamics.

BMEN E1001x Engineering in medicine

Not offered in 2016–2017.

The present and historical role of engineering in medicine and health care delivery. Engineering approaches to understanding organismic and cellular function in living systems. Engineering in

the diagnosis and treatment of disease. Medical imaging, medical devices: diagnostic and surgical instruments, drug delivery systems, prostheses, artificial organs. Medical informatics and organization of the health care system. Current trends in biomedical engineering research.

CHEN E2100x Introduction to chemical engineering

This course serves as an introduction to the chemical engineering profession. Students are exposed to concepts used in the analysis of chemical engineering problems. Rigorous analysis of material and energy balances on open and closed systems is emphasized. An introduction to important processes in the chemical and biochemical industries is provided.

CIEN E3000y The art of structural design

Basic scientific and engineering principles used for the design of buildings, bridges, and other parts of the built infrastructure. Application of these principles to the analysis and design of a number of actual large-scale structures. History of major structural design innovations and the engineers who introduced them. Critical examination of the unique aesthetic/artistic perspectives inherent in structural design. Management, socioeconomic, and ethical issues involved in the design and construction of large-scale structures. Recent developments in sustainable engineering, including green building design and adaptable structural systems.

EAAE E2100x A better planet by design

Introduction to design for a sustainable planet. Scientific understanding of the challenges. Innovative technologies for water, energy, food, materials provision. Multiscale modeling and conceptual framework for understanding environmental, resource, human ecological, and economic impacts and design performance, evaluation. Focus on linkages between planetary, regional, and urban waste, energy, mineral, food, climate, economic, and ecological cycles. Solution strategies for developed and developing country settings.

ELEN E1201x and y Introduction to electrical engineering

Basic concepts of electrical engineering. Exploration of selected topics and their application. Electrical variables, circuit laws, nonlinear and linear elements, ideal and real sources, transducers, operational amplifiers in simple circuits, external behavior of diodes and transistors, first order RC and RL circuits. Digital representation of a signal, digital logic gates, flip-flops. A lab is an integral part of the course.

GRAP E1115x and y Engineering graphics

Focus on 3D software design for applications in engineering design, manufacturing, and graphics presentations. Introduction to 3D design using advanced 3D modeling and visualization technologies using Maya and SolidWorks. The design process includes idea conception and

3D model development, as well as 3D printing and CNC milling manufacturing specifications derived directly from 3D models produced in class. Introduction to the process of creating 3D models that are suitable for 3D printing, CNC milling, injection molding, and laser cutting for buildings. Different models and drawing specifications taught that are required by different manufacturing technologies .

MECE E1001x Mechanical engineering: micro-machines to jumbo jets

Not offered in 2016–2017.

The role of mechanical engineering in developing many of the fundamental technological advances on which today's society depends. Topics include airplanes, automobiles, robots, and modern manufacturing methods, as well as the emerging fields of micro-electro-mechanical machines (MEMS) and nanotechnology. The physical concepts that govern the operation of these technologies will be developed from basic principles and then applied in simple design problems. Students will also be exposed to state-of-the-art innovations in each case study.

MSAE E1001y Atomic-scale engineering of new materials

Not offered in 2016–2017.

An introduction to the nanoscale science and engineering of new materials. The control and manipulation of atomic structure can create new solids with unprecedented properties. Computer hard drives, compact disc players, and liquid crystal displays (LCDs) are explored to understand the role of new materials in enabling technologies. Group problem-solving sessions are used to develop understanding.

Physical Education

Two terms of physical education (*UN1001-UN1002*) are a degree requirement for Columbia Engineering students. No more than 4 points of physical education courses may be counted toward the degree. One point of the physical education requirement can be fulfilled with a Barnard physical education course or a Barnard dance technique course. A student who intends to participate in an intercollegiate sport should register for the appropriate section of *UN1005: Intercollegiate athletics*. Intercollegiate athletes who attend regularly receive 1 point of credit up to the maximum of 4. Those who are advised to follow a restricted or adapted activity program should contact Abbey Lade in the Department of Intercollegiate Athletics and Physical Education. The physical education program offers a variety

of activities in the areas of aquatics, fitness, martial arts, individual and dual lifetime sports, team sports, and outdoor education. Most activities are designed for the beginner/intermediate levels. Advanced courses are indicated on the schedule. The majority of the activities are offered in ten time preferences. However, there are early-morning conditioning activities, Friday-only classes at Baker Athletics Complex, and special courses that utilize off-campus facilities during weekends and vacation periods. The courses offered by the department for each term are included in the online Directory of Classes, and a description of the scheduled activities for each time preference is posted on the www.perec.columbia.edu website. Students may register for only one section of physical education each term.

Advanced Placement

Prior to entering Columbia, students may have taken Advanced Placement examinations through the College Entrance Examination Board (CEEB) in a number of technical and nontechnical areas. A maximum of 16 points may be applied. Students may be assigned to an advanced level course in mathematics or physics based on their AP scores.

In the required pure science areas, the number of advanced placement academic credits awarded to students of engineering and applied science varies from the levels awarded for liberal arts programs, notably in mathematics, physics, chemistry, and computer science. The benefit of advanced placement is acceleration through certain First Year–Sophomore Program requirements and thus the opportunity of taking specialized courses earlier.

Each year the school reviews the CEEB advanced placement curriculum and makes determinations as to appropriate placements, credit, and/or exemption. Please see the Advanced Placement Credit Chart.

International Baccalaureate (IB)

Entering students may be granted 6 points of credit for each score of 6 or 7 on IB Higher Level Examinations if taken in disciplines offered as undergraduate programs at Columbia. Students should consult their adviser

Advanced Placement Credit Chart**

In order to receive AP credit, students must be in possession of appropriate transcripts or scores.

Subject	AP Score	AP Credit	Requirements or Status
Art history	5	3	No exemption from HUMA UN1121
Biology	5	3	No exemption
Chemistry	4 or 5 4 or 5	3 6	Requires completion of CHEM UN1604 with grade of C or better Requires completion of CHEM UN2045-UN2046 with grade of C or better
Computer science A or AB	4 or 5	3	Exemption from COMS W1004
English Language and composition	5	3	No exemption
English Literature and composition	5	3	No exemption
Economics Micro & macro	5 and 4	4*	Exemption from ECON UN1105 (Test must be in both with a score of 5 in one and at least 4 in the other)
French Language	4 or 5	3	
French Literature	4 or 5	3	
German Language	4 or 5	3	
Government and politics United States higher	4 or 5	3*	Requires completion of 3000 level or higher course in the American politics subfield with a C or higher
Government and politics Comparative	4 or 5	3*	Requires completion of 3000 level or higher course in the Comparative politics subfield with a C or higher. Students may be given an exemption, based on AP scores, from only one undergraduate introduction political science class, either POLS UN1201 or POLS UN1501
History European	5	3	
History United States	5	3	
Italian language	4 or 5	3	
Latin literature	5	3	
Mathematics Calculus AB	4 or 5	3	
Mathematics Calculus BC	4	3	
Mathematics Calculus BC	5	6	
Physics C-E&M	4 or 5	3	Requires beginning with PHYS UN2801 and earning grade of C or better
Physics C-MECH	4 or 5	3	Requires beginning with PHYS UN2801 and earning grade of C or better
Physics B	4 or 5	3	No exemption
Spanish Language	4 or 5	3	
Spanish Literature	4 or 5	3	

*AP credits may be applied toward minor requirements.

**2016–2017 Academic Year: the system of course numbering and designated level is in transition; please consult an adviser.

at the James H. and Christine Turk Berick Center for Student Advising for further clarification.

British Advanced Level Examinations

Pending review by the appropriate department at Columbia, students with grades of A or B on British Advanced Level examinations may be granted 6 points of credit if the examinations

were taken in disciplines offered as undergraduate programs at Columbia University. The appropriate transcript should be submitted to the James H. and Christine Turk Berick Center for Student Advising, 403 Lerner.

Other National Systems

Pending review by the appropriate department at Columbia, students

whose secondary school work was in other national systems, such as the French Baccalauréat, may be granted credit in certain disciplines for sufficiently high scores. The appropriate transcript should be submitted to the Center for Student Advising, 403 Lerner.

STUDY ABROAD

Engineering today is a global profession.

Engineers are increasingly being called upon to work with other engineers from across the world, or they may even find themselves living abroad on an overseas assignment. Learning problem-solving skills in a foreign context will help engineering students to expand their horizons, and their adaptability to cross-cultural communication will make them a valuable addition to a team of engineers.

Study abroad allows engineering students to discover the field through the perspective of engineers working in a different language and culture, enabling them to learn the relationship of culture to science and develop the range of transferable skills that employers are seeking today. Study abroad will help students develop intellectually, emotionally, culturally, and socially.

Columbia Engineering undergraduate students can study abroad for either a semester (fall, spring, or summer) or, exceptionally, for a full academic year. Students from every engineering major have studied abroad without adding any time to their course of study at Columbia. Most do so in the spring semester of their sophomore year or in their junior year.

The Office for Undergraduate Student Affairs will help students identify the appropriate choice for their country of interest and their major. The Associate Dean for Undergraduate Student Affairs and Global Programs and departmental advisers will help students with their course equivalencies for approved programs so they can graduate on time. Students can take nontechnical electives overseas, or with departmental permission, they may choose technical electives or courses in their major.

It is essential that students begin planning as early as possible—ideally this would be during their first year. Students are encouraged to meet with the Office of Global Programs to review possible overseas destinations and to decide on an appropriate abroad experience. The SEAS Office of Undergraduate Student Affairs will explain all Columbia Engineering study abroad formalities and requirements. Students must obtain approval from their departmental advisers to ensure that their work abroad meets the requirements of their majors, as well as clearance from their Advising Dean in the James H. and Christine Turk Berick Center for Student Advising.

Eligibility Requirements

In order to participate in a semester-long or yearlong study-abroad program, students must:

- Have at least a 3.0 GPA
 - Be making good progress toward finishing the first and second year requirements
 - Although knowledge of the language of the study abroad country is not a requirement, students are encouraged to have some foreign language skills in order to enhance their cultural competency and their overall study abroad experience.
- NOTE: For programs in countries where the language of instruction is not English, students must take all course work in the local language and will have to show proficiency in that language prior to departure.

Students' study-abroad plans must be approved by the Office of Global Programs by October 15 for spring programs and March 15 for summer, fall and academic-year programs. A review of each student's academic and disciplinary records is conducted as part of this process. Students on academic or disciplinary probation are not permitted to study abroad during the term of their probation. Students must then register for their study abroad with the Office of Global Programs by November 15 for spring programs and March 15 for summer, fall, and academic year programs.

Study-abroad students remain enrolled at Columbia, and tuition is paid to Columbia. Students participating in Columbia-approved programs pay housing costs directly to their host or sponsoring institution. Students receiving financial aid at Columbia will remain eligible for financial aid when they study abroad with Columbia's approval. Students who wish to be considered for financial aid while studying abroad should consult the Office of Financial Aid and Educational Financing, 618 Lerner.

Program Information

Choosing the right university abroad is an important step in planning to study abroad. Study-abroad options vary widely in size, geographical location, academic philosophy, language requirements, living arrangements,

and opportunities for research and internships. Students must establish a set of goals for the study-abroad experience, taking into account their foreign-language skills and adaptability to new environments, as well as their research objectives and professional aspirations.

Students must visit the Office of Global Programs' website to review the various lists of program options and then consult with the SEAS Associate Dean for Undergraduate Student Affairs and Global Programs for specific information or help in choosing an institution that offers the best courses in their engineering major. Early planning is crucial so that study abroad plans can be integrated into the student's curriculum plan.

Summer study-abroad programs allow students to earn credits for language instruction and nontechnical electives. Students can either participate in Columbia-approved summer programs for transfer credit or on Columbia-sponsored programs for direct credit. The Columbia-sponsored summer programs include the Chinese Language Program in Beijing, the Business Chinese and Internship Program in Shanghai, the Italian Cultural Studies Program in Venice, the Columbia University Summer Arabic Language Program in Amman, Jordan, and the Columbia University Programs in Paris at Reid Hall.

Students who wish to have an international experience but are unable to study abroad are encouraged to consider the following options as viable alternatives to gaining such global experience and exposure.

Non-credit-bearing internships, including the CEO program in London, Hong Kong, Singapore, Shanghai, Beijing, and Amman, are coordinated by the Center for Career Education. Please visit the Center's website for more information.

In addition, the Summer Ecosystems Experience for Undergraduate Education through the Center for Environmental Research and Conservation (CERC) provides opportunities for engineering students in Brazil, Puerto Rico, the Dominican Republic, and Jordan. Other internship options may be possible through Columbia Engineering international partner institutions.

Academic Credit

Students in Columbia-sponsored programs receive direct Columbia credit, and the courses and grades appear on students' academic transcripts. These include Reid Hall, Paris; the Berlin Consortium for German Studies; the Kyoto Center for Japanese Studies; the Columbia University Summer Arabic Language Program in Amman, Jordan, and the Tsinghua University program in Beijing.

Credit from approved programs that are not Columbia sponsored is certified as transfer credit toward the Columbia degree upon successful completion of the program verifiable by academic transcript. Students must earn a grade of C or better in order for credits to transfer. Course titles and grades for approved programs do not appear on the Columbia transcript, and the grades are not factored into students' GPAs.

Faculty from the Columbia Engineering academic departments have the responsibility to assess all work completed abroad and make decisions about how these courses fit into major requirements. It is imperative that students gain course-by-course approval from their department prior to departure on a study-abroad program.

COMBINED PLAN PROGRAMS

Office of Undergraduate Admissions
212 Hamilton Hall, MC 2807
1130 Amsterdam Avenue
New York, NY 10027
Phone: 212-854-2522
Fax: 212-854-1209
E-mail: combinedplan@columbia.edu
undergrad.admissions.columbia.edu/apply/combined-plan

Columbia Engineering maintains cooperative program relationships with institutions nationwide and with other Columbia University undergraduate divisions. The Combined Plan programs (3-2 and 4-2) allow students to receive a degree both in the liberal arts and in engineering. Combined Plan students complete the requirements for the liberal arts degree along with required prerequisite course work for their studies in engineering during the three or four years at their liberal arts college before entering the School of Engineering and Applied Science.

They then must complete all the requirements for the B.S. degree within four consecutive semesters.

The Combined Plan Program within Columbia University

Under this plan, the pre-engineering student studies in Columbia College, Barnard College, or the School of General Studies for three or four years, then attends The Fu Foundation School of Engineering and Applied Science for two years, and is awarded the Bachelor of Arts degree and the Bachelor of Science degree in engineering upon completion of the fifth or sixth year. This program is optional at Columbia, but the School recommends it to all students who wish greater enrichment in the liberal arts and pure sciences.

The Combined Plan with Other Affiliated Colleges

There are more than one hundred affiliated liberal arts colleges, including those at Columbia, in which a student can enroll in a Combined Plan program leading to two degrees. Each college requires the completion of a specified curriculum, including major and degree requirements, to qualify for the baccalaureate from that institution. Every affiliated school has a liaison officer who coordinates the program at his or her home institution. Students interested in this program should inform the liaison officer as early as possible, preferably in the first year, in order to receive guidance about completing program requirements. Applicants from nonaffiliated schools are welcome to apply through our competitive review process.

Visit the Office of Undergraduate Admissions website for a complete list of affiliated schools, admission application instructions, information on financial aid, and curriculum requirements for Combined Plan program admission. Please note that no change of major is allowed after an admission decision has been rendered.

See page 25 for information on the 4-2 Master of Science Program, which is administered through the Office of Graduate Student Affairs.

THE JUNIOR-SENIOR PROGRAMS

Students may review degree progress

via DARS (Degree Audit Reporting System) as presented on Student Services Online. Required courses that are not completed are detailed as deficiencies and must be completed during summer session or carried as overload courses in later semesters.

Having chosen their program major in the second semester of their sophomore year, students are assigned to a faculty adviser in the department in which the program is offered. In addition to the courses required by their program, students must continue to satisfy certain distributive requirements, choosing elective courses that provide sufficient content in engineering sciences and engineering design. The order and distribution of the prescribed course work may be changed with the adviser's approval. Specific questions concerning course requirements should be addressed to the appropriate department or division. The Vice Dean's concurrent approval is required for all waivers and substitutions.

Double Major

Students who wish to apply for a second major must consult their advising dean about next steps. A proposal to double major must be approved by both departments and then forwarded to the Vice Dean for Undergraduate Programs for a final decision.

Tau Beta Pi

Tau Beta Pi is the nation's second-oldest honor society, founded at Lehigh University in 1885. With the creed "Integrity and excellence in engineering," it is the only engineering honor society representing the entire engineering profession. Columbia's chapter, New York Alpha, is the ninth oldest and was founded in 1902. Many Columbia buildings have been named for some of the more prominent chapter alumni: Charles Fredrick Chandler, Michael Idvorsky Pupin, Augustus Schermerhorn, and, of course, Harvey Seeley Mudd.

Undergraduate students whose scholarship places them in the top eighth of their class in their next-to-last year or in the top fifth of their class in their last college year are eligible for membership consideration. These scholastically eligible students are further considered on the basis of

personal integrity, breadth of interest both inside and outside engineering, adaptability, and unselfish activity. Benefits of membership include exclusive scholarships and fellowships. Many networking opportunities for jobs and internships are also available, with 230 collegiate chapters and more than 500,000 members in Tau Beta Pi.

Taking Graduate Courses as an Undergraduate

With the faculty adviser's approval, a student may take graduate courses while still an undergraduate in the School. Such work may be credited toward one of the graduate degrees offered by the Engineering Faculty, subject to the following conditions: (1) the course must be accepted as part of an approved graduate program of study; (2) the course must not have been used to fulfill a requirement for the B.S. degree and must be so certified by the Dean; and (3) the amount of graduate credit earned by an undergraduate cannot exceed 15 points. Undergraduates may not take CVN courses.

The Bachelor of Science Degree

Students who complete a four-year sequence of prescribed study are awarded the Bachelor of Science degree. The general requirement for the Bachelor of Science degree is the completion of a minimum of 128 academic credits with a minimum cumulative grade-point average (GPA) of 2.0 (C) at the time of graduation. The program requirements, specified elsewhere in this bulletin, include the first-year-sophomore course requirements, the major departmental requirements, and technical and nontechnical elective requirements. Students who wish to transfer points of credit may count no more than 68 transfer points toward the degree and must satisfy the University's residence requirements by taking at least 60 points of credit while enrolled in The Fu Foundation School of Engineering and Applied Science. Courses may not be repeated for credit unless it is stated otherwise in the course description.

The bachelor's degree in engineering and applied science earned at Columbia University prepares students to enter a wide range of professions. Students are, however, encouraged to consider

graduate work, at least to the master's degree level, which is increasingly considered necessary for many professional careers.

The Engineering Accreditation Commission (EAC) of ABET, an organization formed by the major engineering professional societies, accredits university engineering programs on a nationwide basis. Completion of an accredited program of study is usually the first step toward a professional engineering license. Advanced study in engineering at a graduate school sometimes presupposes the completion of an accredited program of undergraduate study.

The following undergraduate programs are accredited by the EAC of ABET: biomedical engineering, chemical engineering, civil engineering, Earth and environmental engineering, electrical engineering, and mechanical engineering.

Minors

Columbia Engineering undergraduates may choose to add minors to their programs. This choice should be made in the fall of their sophomore year, when they also decide on a major.

In considering a minor, students must understand that all minors are not, and cannot, be available to all students. In addition, the School cannot guarantee that a selected minor can be completed within the usual residence period needed for a major. Indeed, students choosing minors should expect to encounter scheduling difficulties. The potential for the successful completion of a minor depends on the student's major and the minor chosen, as well as the course schedules and availability, which may change from year to year. The list of minors, as well as their requirements, appear on pages 198–202.

PROGRAMS IN PREPARATION FOR OTHER PROFESSIONS

James H. and Christine Turk Berick Center for Student Advising
403 Lerner Hall, MC 1201
Phone: 212-854-6378
E-mail: preprofessional@columbia.edu
cc-seas.columbia.edu/preprofessional/

The Fu Foundation School of Engineering and Applied Science prepares its students to enter any number of graduate programs and professions outside of what is generally thought of as the engineering field. In an increasingly technological society, where the line between humanities and technology is becoming blurred, individuals with a thorough grounding in applied mathematics and the physical and engineering sciences find themselves highly sought after as professionals in practically all fields of endeavor.

Engineering students interested in pursuing graduate work in such areas as architecture, business, education, journalism, or law will find themselves well prepared to meet the generally flexible admissions requirements of most professional schools. Undergraduate students should, however, make careful inquiry into the kinds of specific preparatory work that may be required for admission into highly specialized programs such as medicine.

Premed

Medical, dental, and other health professional schools prefer that undergraduates complete a four-year program of study toward the bachelor's degree. All health professional schools require prerequisite course work, but they do not prefer one type of major or scholarly concentration. Students with all types of engineering backgrounds are highly valued.

It is important to note, however, that each medical school in the United States and Canada individually determines its own entrance requirements, including prerequisite coursework and/or competencies. Each medical school also sets its own rules regarding acceptable courses or course equivalents. It is therefore essential that students plan early and confirm the premedical requirements for those schools to which they intend to apply. The Engineering curriculum covers many of the prerequisite courses required by medical schools, however, in addition to completing the mathematics, chemistry, and physics courses required by the First Year–Sophomore Program, most schools ask for a full year of organic chemistry, a full year of biology, a full year of English, a

semester of statistics, and a semester of biochemistry. Advanced Placement credit is accepted in fulfillment of these requirements by some schools but not all. Students are responsible for monitoring the requirements of each school to which they intend to apply. Generally, students with Advanced Placement credit are strongly advised to take further courses in the field in which they have received such credit.

In addition to medical school requirements, all medical schools currently require applicants to sit for the Medical College Admissions Test (MCAT). A new format of this exam was introduced in the spring of 2015, for which recommended minimum preparation is:

- One year of general chemistry and general chemistry lab
- One year of organic chemistry and organic chemistry lab
- One year of introductory biology and biology lab
- One year of general physics and physics lab
- One semester of introductory psychology

As you prepare for this path, you should consult regularly with both your assigned adviser and one of the premedical advisers in the James H. Christine Turk Berick Center for Student Advising. These individuals will help to guide you in your course selection and planning, and introduce you to extracurricular and research opportunities related to your interests in health and medicine. Preprofessional Advising maintains an online list of many different clinical volunteer and research opportunities across New York City and beyond. Exploration of the career and sustained interactions with patients is viewed by many medical schools as essential preparation and therefore students are strongly encouraged to spend time volunteering/working in clinical and research environments before applying to medical school.

Students must apply for admission to health professional schools more than one year in advance of the entry date. Students who are interested in going directly on to health professional schools following graduation should complete all prerequisite courses

required for the MCAT by the end of the junior year. It is entirely acceptable (and most common) for students to take time between undergraduate and health professional school and thus delay application to these schools for one or more years. Students planning to apply to medical or dental school should be evaluated by the Premedical Advisory Committee prior to application. A Premedical Advisory Committee application is made available each year in December. For more information regarding this process and other premedical-related questions, please consult with a premedical adviser in the Berick Center for Student Advising or peruse their website: <https://www.cc-seas.columbia.edu/preprofessional/health/>

Prelaw

Students fulfilling the School of Engineering and Applied Science's curriculum are well prepared to apply to and enter professional schools of law, which generally do not require any specific prelaw course work. Schools of law encourage undergraduate students to complete a curriculum characterized by rigorous intellectual training involving relational, syntactical, and abstract thinking. While selecting courses, keep in mind the need to hone your writing skills, your communication skills, and your capacity for logical analysis.

While engineering students may find interests in many areas of the law, for intellectual property and patent law, a science and technology background will be greatly valued if not essential.

Urban Teaching: New York State Initial Certification in Adolescence Education Grades 7–12 for Teachers of Mathematics and the Sciences or in Elementary Education Grades 1–6

Barnard College Education Program
335-336 Milbank Hall
3009 Broadway
New York, NY 10027
Phone: 212-854-7072
education.barnard.edu

The Barnard Education Program provides courses leading to certification to teach in New York State (with reciprocal agreements with 41 other states) at either the elementary

or secondary level. Students gain experience and develop skills in urban school classrooms. Required course work includes psychology and education, a practicum, and student teaching, totaling 23–26 points of credit depending on the level of certification sought.

Certification to teach mathematics requires 36 points in mathematics. Pure science courses required are: 36 points in the sciences, of which 18 must be in the area of the certification sought: chemistry, biology, physics, or Earth science.

Deadline for application, which includes an essay and letters of recommendation, is the first Monday in March of the student's sophomore year. This allows program faculty to support students through program planning to ensure that students can meet the requirements for certification. However, when space allows, applications will be considered through the fall of the junior year. Applications from juniors are due no later than the first Monday in October. Students who plan to study abroad during the spring of their junior year should apply during the fall semester of their sophomore year. Students should decide on their interest in teacher certification by the end of the first year in order to start course work in the sophomore year.

JOINT PROGRAMS

The 4-1 Program at Columbia College

Students who are admitted as first-year students to the School of Engineering and Applied Science and subsequently complete the four-year program for the Bachelor of Science degree have the opportunity to apply for admission to either Columbia College or Barnard College and, after one additional year of study, receive the Bachelor of Arts degree.

The program will be selective, and admission will be based on the following factors: granting of the B.S. at Columbia Engineering at the end of the fourth year; fulfillment of the College Core requirements by the end of the fourth year at the School; a minimum GPA of 3.0 in the College Core and other courses; and the successful

completion of any prerequisites for the College major or concentration. To be admitted to the program, a plan needs to be in place for the student to complete the major or concentration by the end of their fifth year.

Interested students should contact their advising dean for further information.

School of International and Public Affairs

The Fu Foundation School of Engineering and Applied Science and the School of International and Public Affairs offer a joint program enabling a small number of students to complete

the requirements for the degrees of Bachelor of Science and Master of International Affairs in five years instead of six. Not only an excellent academic record but also maturity, fluency in an appropriate foreign language, and pertinent experience will determine admission to this program. For more information, please contact your advising dean.

UNDERGRADUATE ADMISSIONS

Office of Undergraduate Admissions
212 Hamilton Hall, MC 2807
1130 Amsterdam Avenue
New York, NY 10027

Phone: 212-854-2522

Fax: 212-854-3393

E-mail: ugrad-ask@columbia.edu
undergrad.admissions.columbia.edu

For information about undergraduate admissions, please visit the Office of Undergraduate Admissions website or contact the office by phone or e-mail.

The 2016–2017 tuition and fees are estimated. Tuition and fees are prescribed by statute and are subject to change at the discretion of the Trustees.

University charges such as tuition, fees, and residence hall and meal plans are billed in the first Student Account Statement of the term, which is sent out in July and December of each year for the upcoming term. This account is payable and due in full on or before the payment due date announced in the Statement, typically at the end of August or early January before the beginning of the billed term. Any student who does not receive the first Student Account Statement is expected to pay at registration.

If the University does not receive the full amount due for the term on or before the payment due date of the first Statement, a late payment charge of \$150 will be assessed. An additional charge of 1 percent per billing cycle may be imposed on any amount past due thereafter.

Students with an overdue account balance may be prohibited from registering, changing programs, or obtaining a diploma or transcripts. In the case of persistently delinquent accounts, the University may utilize the services of an attorney and/or collection agent to collect any amount past due. If a student's account is referred for collection, the student may be charged an additional amount equal to the cost of collection, including reasonable attorney's fees and expenses incurred by the University.

TUITION

Undergraduate students enrolled in The Fu Foundation School of Engineering and Applied Science pay a flat tuition charge of \$26,239 per term, regardless of the number of course credits taken.

MANDATORY FEES

Orientation fee: \$420 (one-time charge in the first term of registration)
 Student Life fee: \$779 per term
 Health Service fee: \$510 per term
 International Services charge: \$70 per term (international students only)
 Transcript fee: \$105 (one-time charge)

OTHER FEES

Application and late fees:

- Application for undergraduate admission: \$85
- Application for undergraduate transfer admission: \$85
- Late registration fee during late registration: \$50;
after late registration: \$100

Books and course materials: Depends upon course

Laboratory fees: See course listings

Room and board (estimated): \$12,000

HEALTH INSURANCE

Columbia University offers the Student Medical Insurance Plan, which provides both Basic and Comprehensive levels of coverage.

Full-time students are automatically enrolled in the Basic level of the Plan and billed for the insurance premium in addition to the Health Service fee. Visit the Columbia Health website at health.columbia.edu for detailed information about medical insurance coverage options and directions for making confirmation, enrollment, or waiver requests.

PERSONAL EXPENSES

Students should expect to incur miscellaneous personal expenses for such items as clothing, linen, laundry, dry cleaning, and so forth. Students should also add to the above expenses the cost of two round trips between home and the University to cover travel during the summer and the month-long, midyear break.

The University advises students to open a local bank account upon arrival in New York City. Since it often takes as long as three weeks for the first deposit to clear, students should plan to cover immediate expenses using either a credit card, traveler's checks, or cash draft drawn on a local bank. Students are urged not to arrive in New York without sufficient start-up funds.

LABORATORY CHARGES

Students may need to add another \$100 to \$300 for drafting materials or laboratory fees in certain courses. Each student taking laboratory courses must furnish, at his or her own expense, the necessary notebooks, blank forms, and similar supplies.

In some laboratory courses, a fee is charged to cover expendable materials and equipment maintenance. Students engaged in special tests, investigations, theses, or research work are required to meet the costs of expendable materials as may be necessary for this work and in accordance with such arrangements as may be made between the student and the department immediately concerned.

DAMAGES

All students will be charged for damage to instruments or apparatus caused by their carelessness. The amount of the charge will be the actual cost of repair, and, if the damage results in total loss of the apparatus, adjustment will be made in the charge for age or condition. To ensure that there may be no question as to the liability for damage, students should note whether the apparatus is in good condition before use and, in case of difficulty, request instruction in its proper operation. Where there is danger of costly damage, an instructor should be requested to inspect the apparatus. Liability for breakage will be decided by the instructor in charge of the course.

When the laboratory work is done by a group, charges for breakage will be divided among the members of the group. The students responsible for any damage will be notified that a charge is being made against them.

The amount of the charge will be stated at that time or as soon as it can be determined.

TUITION AND FEE REFUNDS

Students who make a complete withdrawal from a term are assessed a withdrawal fee of \$75. Late fees, application fees, withdrawal fees, tuition deposits, special fees, computer fees, special examination fees, and transcript fees are not refundable.

The Health Service Fee, Health Insurance Premium, University facilities fees, and student activity fees are not refundable after the change of program period.

Students who withdraw within the first 60 percent of the academic period are subject to a refund calculation, which refunds a portion of tuition based on the percentage of the term remaining after the time of withdrawal. This calculation is made from the date the student's written notice of withdrawal is received by the Dean's Office.

Percentage Refund for Withdrawal during First Nine Weeks of Term

Prorated for calendars of a different duration:

1st week	100%
2nd week	100%
3rd week	90%
4th week	80%
5th week	70%
6th week	60%
7th week	50%
8th week	40%
9th week and after	0%

For students receiving federal student aid, refunds will be made to the federal aid programs in accordance with Department of Education regulations.

Refunds will be credited in the following order:
Federal Unsubsidized Stafford Loans
Federal Stafford Loans
Federal Perkins Loans
Federal PLUS Loans (when disbursed through the University)
Federal Pell Grants
Federal Supplemental Educational Opportunity Grants
Other Title IV funds

Withdrawing students should be aware that they will not be entitled to any portion of a refund until all Title IV programs are credited and all outstanding charges have been paid.

Office of Financial Aid and
Educational Financing
618 Lerner Hall
2920 Broadway
Mailing: 100 Hamilton
1130 Amsterdam Avenue, MC 2802
New York, NY 10027
Monday–Friday: 9:00 a.m.–5:00 p.m.

Phone: 212-854-3711
Fax: 212-854-5353
E-mail: ugrad-finaid@columbia.edu
cc-seas.financialaid.columbia.edu

Columbia is committed to meeting the full demonstrated financial need for all applicants admitted as first-year students. Financial aid is available for all four undergraduate years, provided that students continue to demonstrate financial need. International students who did not apply for financial aid in their first year are not eligible to apply

for financial aid in any subsequent years.

All transfer applicants who are citizens or permanent residents of the United States or students granted refugee visas by the United States are considered for admission in a need-blind manner. Foreign transfer candidates applying for aid must understand that such aid is awarded on an extremely limited basis. Columbia meets 100% of demonstrated financial need for admitted transfer students and does not give any scholarships for academic, athletic, or artistic merit.

Please visit the Financial Aid website at cc-seas.financialaid.columbia.edu/ for more information on financial aid, including requirements and application instructions.

Satisfactory Academic Progress

Columbia University complies with federal SAP regulations. To be eligible for Federal Student Aid (Federal Pell Grant, Federal SEOG, Federal Work-Study, Federal Perkins Loan, Federal Direct/PLUS loan), an otherwise eligible student must meet or exceed the SAP standards set by his or her school or program at the time SAP is assessed. The SAP policy may be found online at sfs.columbia.edu/central-sap-policy.

Graduate Studies



Graduate programs of study in The Fu Foundation School of Engineering and Applied Science are not formally prescribed, but are planned to meet the particular needs and interests of each individual student. Departmental requirements for each degree, which supplement the general requirements given below, appear in the sections on individual graduate programs.

Applicants for a graduate program are required to have completed an undergraduate degree and to furnish an official transcript as part of the admissions application. Ordinarily the candidate for a graduate degree will have completed an undergraduate course in the same field of engineering in which he or she seeks a graduate degree. However, if the student's interests have changed, it may be necessary to make up such basic undergraduate courses as are essential to graduate study in his or her new field of interest.

No more than one term of graduate-level course work or, in the case of part-time students, no more than 15 points of credit of graduate-level course work, completed before the program is approved, may be counted toward the degree. Students registered in the School have a minimum requirement for each Columbia degree of 30 points of credit of course work completed at Columbia University. The student must enroll for at least 15 of these points while registered as a matriculating student in a degree program in the Engineering School. (See also the section Special Nondegree Students and the chapter Columbia Video Network.) Students wishing to change from the Ph.D. degree to the Eng.Sc.D. degree must

therefore enroll for at least 15 points while registered in the School. For residence requirements for students registered in the Graduate School of Arts and Sciences or those wishing to change from the Eng.Sc.D. degree to the Ph.D. degree, see the bulletin of the Graduate School of Arts and Sciences.

Students admitted to graduate study are expected to enter upon and continue their studies in each succeeding regular term of the academic year. Any such student who fails to register for the following term will be assumed to have withdrawn unless a leave of absence has been granted by the Office of Graduate Student Affairs.

While many candidates study on a full-time basis, it is usually possible to obtain all or a substantial part of the credit requirement for the master's or Eng.Sc.D. degrees through part-time study.

Under special conditions, and with the prior approval of the department of his or her major interest and of the Assistant Dean or Director, a student may be permitted to ' a required subject at another school. However, credit for such courses will not reduce the 30-point minimum that must be taken.

For graduation, a candidate for any degree except a doctoral degree must file an Application for Degree or Certificate on the date specified in the Academic Calendar. Candidates for a doctoral degree must apply for the final examination. If the degree is not earned by the next regular time for the issuance of diplomas subsequent to the date of filing, the application must be renewed. Degrees are awarded three times a year—in October, February, and May.

THE MASTER OF SCIENCE DEGREE

The Master of Science degree is offered in many fields of engineering and applied science upon the satisfactory completion of a minimum of 30 points of credit of approved graduate study extending over at least one academic year.

While a suitable Master of Science program will necessarily emphasize some specialization, the program should be well balanced, including basic subjects of broad importance as well as theory and applications. The history of modern economic, social, and political institutions is important in engineering, and this is recognized in the prescribed undergraduate program of the School. If the candidate's undergraduate education has been largely confined to pure science and technology, a program of general studies, totaling from 6 to 8 points, may be required. Supplementary statements covering these special requirements are issued by the School's separate departments. An applicant who lacks essential training will be required to strengthen or supplement the undergraduate work by taking or repeating certain undergraduate courses before proceeding to graduate study. No graduate credit (that is, credit toward the minimum 30-point requirement for the Master of Science degree) will be allowed for such subjects. Accordingly, Master of Science programs may include from 35 to 45 points and may require three terms for completion. Doctoral research credits cannot be used toward M.S. degree requirements.

All degree requirements must be completed within five years of

the beginning of graduate study. Under extraordinary circumstances, a written request for an extension of this time limit may be submitted to the student's department for approval by the department chairman and the Assistant Dean or Director. A minimum grade-point average of 2.5 is required for the M.S. degree. A student who, at the end of any term, has not attained the grade-point average required for the degree may be asked to withdraw.

After the first semester of enrollment, an M.S. student may submit an application to apply and transfer to another academic program. If the student is not successful with the application process, then he or she must make sure requirements for the original academic program are completed.

The 4-2 Master of Science Program

The 4-2 Master of Science Program provides the opportunity for students holding bachelor's degrees from affiliated liberal arts colleges (see the listing under the heading The Combined Plan Program with Other Affiliate Colleges) with majors in mathematics, physics, chemistry, or certain other physical sciences to receive the M.S. degree after two years of study at Columbia in the following fields of engineering and applied science: biomedical, chemical, civil, computer science, Earth and environmental, electrical, industrial, and mechanical engineering; applied physics; applied mathematics; engineering mechanics; operations research; and materials science.

Each applicant must produce evidence of an outstanding undergraduate record, including superior performance in physics and mathematics through differential equations. The program of study will be individually designed in consultation with a faculty adviser and will integrate undergraduate work with the field of engineering or applied science the student chooses to follow. During the first year, the program will consist primarily of basic undergraduate courses; during the second year, of graduate courses in the selected field. The student must complete at least 30 credits of graduate study to qualify for the degree.

A student whose background may

require supplementary preparation in some specific area, or who has been out of school for a considerable period, will have to carry a heavier than normal course load or extend the program beyond two years.

Graduates of the 4-2 Master of Science program may not be eligible to take the Fundamentals of Engineering (FE) exam if their undergraduate degree is not in engineering or a related field. Students should also check with individual state boards to determine eligibility requirements for employment.

Please contact the Office of Graduate Student Affairs, The Fu Foundation School of Engineering and Applied Science, 530 S.W. Mudd, MC 4718, 500 West 120th Street, New York, NY 10027; you should also contact your home institution's Combined Plan liaison for program information. You may, in addition, e-mail questions to seasgradmit@columbia.edu.

Dual Degree Program with the School of Journalism in Computer Science

The Graduate School of Journalism and the Engineering School offer a dual degree program leading to the degrees of Master of Science in Journalism and the Master of Science in Computer Science. (See Computer Science.)

Joint Program with the School of Business in Industrial Engineering

The Graduate School of Business and the Engineering School offer a joint program leading to the degrees of Master of Business Administration and Master of Science in Industrial Engineering. (See Industrial Engineering and Operations Research.)

Master of Science Program in Data Science

The Data Science Institute is housed in the Engineering School and encompasses the interdisciplinary expertise of nine schools within Columbia University, including the Engineering School, the Graduate School of Arts and Sciences, the Journalism School, the Graduate School of Business, the Graduate School of Architecture, Planning and Preservation, the School of International and Public Affairs, the

Medical Center, the Mailman School of Public Health, and the Law School. The Institute offers a master's degree program allowing students to select an elective concentration of study incorporating one of the six centers: Cybersecurity, Financial and Business Analytics, Foundations of Data Science, Health Analytics, New Media, and Smart Cities. Students can also pursue an Entrepreneurship track.

Master of Science Program in Management Science and Engineering

In collaboration with the Graduate School of Business, the Industrial Engineering and Operations Research department offers a unique master's degree program in which students take business and engineering courses. (See Industrial Engineering and Operations Research.)

DOCTORAL DEGREES: ENG.SC.D. AND PH.D.

Two doctoral degrees in engineering are offered by the University: the Doctor of Engineering Science, administered by The Fu Foundation School of Engineering and Applied Science and the Doctor of Philosophy, administered by the Graduate School of Arts and Sciences. Both doctoral programs are subject to review by the Committee on Instruction of the School. Doctoral students may submit a petition to the Office of Graduate Student Affairs to change from the Eng.Sc.D. degree to the Ph.D. degree or from the P.D. degree to the Eng.Sc.D. degree. The petition must be submitted within the first year of enrollment or by the completion of 30 points. Any petitions submitted after this period will not be considered. Doctoral degree status can be changed only once; students, therefore, must determine which doctoral degree program is most appropriate for their academic and professional endeavours.

Departmental requirements may include comprehensive written and oral qualifying examinations. A student must have a satisfactory grade-point average to be admitted to the doctoral qualifying examination. Thereafter, the student must write a dissertation embodying original research under the sponsorship

of a member of his or her department and submit it to the department. If the department recommends the dissertation for defense, the student applies for final examination, which is held before an examining committee approved by the appropriate Dean's Office. This application must be made at least three weeks before the date of the final examination.

The defense of the dissertation constitutes the final test of the candidate's qualifications. It must be demonstrated that the candidate has made a contribution to knowledge in a chosen area. In content the dissertation should, therefore, be a distinctly original contribution in the selected field of study. In form it must show the mastery of written English, which is expected of a university graduate.

For the Ph.D. Degree

A student must obtain the master's degree (M.S.) before enrolling as a candidate for the Ph.D. degree. Application for admission as a doctoral candidate may be made while a student is enrolled as a master's degree candidate. Candidates for the Ph.D. degree must register full time and complete six Residence Units. The minimum requirement in course work for the doctoral degree is 60 points of credit beyond the bachelor's degree. A master's degree from an accredited institution may be accepted in the form of advanced standing as the equivalent of one year of residence (30 points of credit and two Residence Units). An application for advanced standing must be completed during the first semester of study. Ph.D. candidates will be required to complete not less than 30 additional points of credit in residence for a letter grade beyond the M.S.

Ph.D. candidates should obtain a copy of the bulletin of the Graduate School of Arts and Sciences, in which are printed the requirements of the department of major interest.

For the Eng.Sc.D. Degree

A student must obtain the master's degree (M.S.) before enrolling as a candidate for the Eng.Sc.D. degree. The minimum requirement in course work for the doctoral degree is 60 points of credit beyond the bachelor's

degree. Eng.Sc.D. candidates will be required to complete not less than 30 additional points of credit in residence beyond the M.S. for a letter grade. A master's degree from an accredited institution may be accepted in the form of advanced standing as the equivalent of 30 points of credit. Candidates for the Eng.Sc.D. degree must, in addition to the 60-point requirement, accumulate 12 points of credit in the departmental course *E9800: Doctoral research instruction* (see below). The candidate for the degree of Doctor of Engineering Science must submit evidence that his or her dissertation has been filed in compliance with requirements set by the faculty of Engineering and Applied Science.

Doctoral Research Instruction

An Eng.Sc.D. candidate is required to complete 12 credits in the departmental course *E9800: Doctoral research instruction* in accordance with the following guidelines:

1. After obtaining a master's degree or advanced standing, at which time the student begins doctoral research, the student is eligible to register for *E9800* (3, 6, 9, or 12 points of credit).
2. Registration for *E9800* at a time other than that prescribed above is not permitted, except by written permission of the Dean.
3. The 12 points of *E9800* required for the Eng.Sc.D. degree do not count toward the minimum residence requirements, e.g., 30 points beyond the master's degree or 60 points beyond the bachelor's degree.
4. If a student is required to take course work beyond the minimum residence requirements, the 12 points of doctoral research instruction must still be taken in addition to the required course work.
5. A student must register continuously through the fall and the spring terms. This requirement does not include the summer session.

Completion of Requirements

The requirements for the Eng.Sc.D. degree must be completed in no more than seven years. The seven-year time period begins at the time the student

becomes a candidate for the Eng.Sc.D. degree and extends to the date on which the dissertation defense is held.

Extension of the time allowed for completion of the degree may be granted on recommendation of the student's sponsor and the department chairman to the Dean when special circumstances warrant. Such extensions are initiated by submitting a statement of work in progress and a schedule for completion together with the sponsor's recommendation to the department chairman.

Please contact the Office of Graduate Student Affairs for more information.

SPECIAL NONDEGREE STUDENTS

Qualified persons who are not interested in a degree program but who wish only to take certain courses may be permitted to register as special students, provided facilities are available.

Many graduate courses in The Fu Foundation School of Engineering and Applied Science are offered in the late afternoon and evening in order to make them available to working individuals who wish to further their knowledge in the areas of engineering and applied science. Individuals who find it difficult or impossible to attend classes on the Columbia campus may be able to receive instruction from the School through the Columbia Video Network without leaving their work sites. Individuals interested in this program should read the section describing the distance learning Columbia Video Network (CVN), which follows in this bulletin.

Special students receive grades and must maintain satisfactory attendance and performance in classes or laboratories and will be subject to the same rules as degree candidates. Should a special student decide to pursue a degree program, work completed as a special student may be considered for advanced standing, but no more than 15 points of course work completed as a special student may be counted toward a graduate degree.

For additional information and regulations pertaining to special students, see Graduate Admissions.

Columbia Video Network
540 S. W. Mudd, MC 4719
500 West 120th Street
New York, NY 10027

Phone: 212-854-6447
E-mail: info@cvn.columbia.edu
cvn.columbia.edu

BACKGROUND

Continuing a long-standing tradition of academic excellence and innovation, Columbia University's Fu Foundation School of Engineering and Applied Science established the Columbia Video Network (CVN) in 1986 to meet a growing need within the engineering community for a graduate distance education program. Classes and degrees offered through CVN are fully accredited; the degrees are granted by Columbia University.

Classes available through CVN are taught on campus by Columbia University faculty in electronic classrooms. Faculty and students meet in classrooms equipped with cameras, electronic writing tablets, and SMART™ boards. The recorded lectures are fully downloadable for study at home, office, or on the road.

CVN students take the same classes, have the same homework assignments, take the same exams, and earn the same degrees as on-campus students in Master of Science (M.S.) programs.

COURSE OFFERINGS AND DEGREE PROGRAMS

CVN makes select SEAS graduate courses available to off-campus students in autumn (September–December) and spring (January–May) terms. CVN administrators work closely with faculty representatives from each department to select the classes that best fit the needs of new and continuing students around the world. During the summer semester (and

on request in the autumn and spring terms), CVN makes prerecorded courses available. SEAS currently offers M.S. degrees in the following disciplines through CVN:

- Applied physics
- Applied physics and applied math
- Biomedical engineering
- Chemical engineering
- Civil engineering
- Computer science
- Earth and environmental engineering
- Electrical engineering
- Industrial engineering—systems engineering
- Materials science and engineering
- Mechanical engineering
- Operations research
- Operations research—methods in finance

In addition, students admitted to the Doctor of Engineering Science can complete the course work component of the program via CVN.

STUDENT REGISTRATION

Students who have earned an undergraduate degree in engineering, mathematics, or related field can apply to take classes for credit or audit without first enrolling in a degree program at the University or taking the GRE or TOEFL exams by registering as nondegree students. CVN also offers Certification of Professional Achievement programs in various fields, which may lead to study in a related M.S. program.

Although you need not be admitted to a degree program to begin taking classes through CVN, you should apply as soon as possible if you would like to earn a degree from Columbia University; up to 6 credits taken as a CVN nondegree student may be counted toward a degree when applying through CVN, subject to the approval of the student's departmental

adviser. Earning credit as a nondegree student does not guarantee acceptance into a degree program.

Only CVN students may transfer up to 6 credits from another university toward an M.S., subject to the approval of the student's adviser and the department.

Columbia University students admitted to an on-campus program are not eligible to take CVN courses.

PROGRAM BENEFITS

The CVN program allows working professionals to enroll in courses and earn graduate engineering degrees without leaving their communities, their families, or their jobs. The key component of CVN is flexibility without compromise to the high-caliber teaching, resources, and standards inherent in The Fu Foundation School of Engineering and Applied Science. CVN students are a part of the Columbia community and may take classes on campus. To further enhance the sense of community, CVN uses the Canvas Learning Management System to provide a place where CVN students and faculty can communicate. Homework and exams are submitted and graded there, and course notes and other reference materials are available for downloading.

Professors and teaching assistants are available via e-mail, phone, or online office hours to address academic questions. CVN's administrative staff is available to assist with registration procedures, technical queries, and academic advising, so working professionals can devote their energies to their studies, their families, and their careers.

Office of Graduate Student Affairs
530 S. W. Mudd, MC 4708
500 West 120th Street
New York, NY 10027

Phone: 212-854-6438
Fax: 212-854-5900
E-mail: seasgradmit@columbia.edu
gradengineering.columbia.edu

The basic requirement for admission as a graduate student is a bachelor's degree received from an institution of acceptable standing. Ordinarily, the applicant will have majored in the field in which graduate study is intended, but in certain programs, preparation in a related field of engineering or science is acceptable. The applicant will be admitted only if the undergraduate record shows promise of productive and effective graduate work.

Students who hold an appropriate degree in engineering may apply for admission to study for the Ph.D. degree. However, students are required to obtain the master's degree first. Applications for admission as a doctoral candidate may be made after completion of 15 points of work as a candidate for the master's degree.

Students may be admitted in one of the following five classifications: candidate for the M.S. degree, candidate for the M.S. degree leading to the Ph.D. degree, candidate for the Doctor of Engineering Science degree, candidate for the Doctor of Philosophy degree (see also the bulletin of the Graduate School of Arts and Sciences), or special student (not a degree candidate). Note: Not more than 15 points of credit completed as a special nondegree student may be counted toward a degree.

APPLICATION REQUIREMENTS

Applicants must submit an online application and required supplemental materials, as described below. The applicant must obtain one official transcript from each postsecondary institution attended and upload it to the online application. Consideration for admission will be based not only on the completion of an earlier course of study, but also upon the quality of the record presented and upon such evidence as can be obtained concerning the candidate's personal fitness to pursue professional work.

Additionally, candidates must provide three letters of recommendation and the results of required standardized exams. The Graduate Record Examination (general) is required for all candidates. GRE scores are valid for five years from the test date. The Test of English as a Foreign Language (TOEFL), the International English Language Testing System (IELTS), or the Pearson Test of English (PTE) is required of all candidates who received their bachelor's degree in a country in which English is not the official and spoken language. TOEFL, IELTS, and PTE scores are valid for two years from the test date. Applicants can only apply to one degree program per admission term.

ENGLISH PROFICIENCY

The Office of Graduate Student Affairs no longer requires students to demonstrate English proficiency as a graduation requirement at The Fu Foundation School of Engineering and Applied Science. Regardless of TOEFL, IELTS, or PTE scores submitted for admission, students should continue to work on maintaining adequate verbal and/or written abilities for successful integration within their classes and future professional

endeavors. Students are highly encouraged to be proactive about addressing their English proficiency by utilizing the many resources available within Columbia University and throughout New York City.

Students have the option of enrolling in courses offered through the American Language Program (ALP) at Columbia University. However, course credits earned through ALP do not count toward the minimum engineering academic course work requirements. Enrollment in ALP courses is solely the financial responsibility of the student. As a rule, ISSO will not permit students to drop courses or fall below full-time registration for language proficiency deficiencies.

APPLICATION FEE

The nonrefundable application fee for all graduate degree and nondegree programs is \$85.

GRADUATE ADMISSION CALENDAR

Applicants are admitted twice yearly, for the fall and spring semesters.

- Fall admission application deadlines: *December 15* for Ph.D., Eng.Sc.D., and M.S. leading to Ph.D. programs and *February 15* for most M.S. only and nondegree applicants. Please visit the Office of Graduate Student Affairs website for specific M.S. only program deadlines.
- Spring admission application deadline: *October 1* for all departments and degree levels.

Applicants who wish to be considered for scholarships, fellowships, and assistantships should file complete applications for fall admission.

EXPRESS APPLICATION

Columbia Engineering seniors already enrolled in a B.S. program with a minimum GPA of 3.5 are eligible to submit an express application.

This online application, which waives the submission of GRE scores, letters of recommendation, and official transcripts, streamlines and simplifies the application process for graduate study. Contact your academic department or the Office of Graduate Student Affairs for further details.

ONE-TERM SPECIAL STUDENT STATUS

Individuals who meet the eligibility requirements, who are U.S. citizens

or U.S. permanent residents, and who wish to take courses for enrichment, may secure faculty approval to take up to two graduate-level courses for one term only as a one-term special student. This option is also appropriate for individuals who missed application deadlines. Applications for special student status are available at the Office of Graduate Student Affairs and must be submitted during the first week of the fall or spring semester.

If a one-term special student subsequently wishes either to continue taking classes the following term or to become a degree candidate, a formal application must be made through the Office of Graduate Student Affairs.

TRANSFER APPLICANTS

Master degree students are not eligible for transfer credits.

Students possessing a conferred M.S. degree may be awarded two residence units toward their Ph.D., as well as 30 points of advanced standing toward their Ph.D. or Eng.Sc.D. with approval from the academic department and the Office of Graduate Student Affairs.

The 2016–2017 tuition and fees are estimated. Tuition and fees are prescribed by statute and are subject to change at the discretion of the Trustees.

University charges such as tuition, fees, and residence hall and meal plans are billed in the first Student Account Statement of the term, which is sent out in July and December of each year for the upcoming term. This account is payable and due in full on or before the payment due date announced in the Statement, typically at the end of August or early January before the beginning of the billed term. Any student who does not receive the first Student Account Statement is expected to pay at registration.

If the University does not receive the full amount due for the term on or before the payment due date of the first Statement, a late payment charge of \$150 will be assessed. An additional charge of 1 percent per billing cycle may be imposed on any amount past due thereafter.

Students with an overdue account balance may be prohibited from registering, changing programs, or obtaining a diploma or transcripts. In the case of persistently delinquent accounts, the University may utilize the services of an attorney and/or collection agent to collect any amount past due. If a student's account is referred for collection, the student may be charged an additional amount equal to the cost of collection, including reasonable attorney's fees and expenses incurred by the University.

TUITION

Graduate students enrolled in M.S. and Eng.Sc.D. programs pay \$1,858 per credit, except when a special fee is fixed. Graduate tuition for Ph.D. students is \$21,772 per Residence Unit. The Residence Unit, full-time registration for one semester rather than for individual courses (whether or not the student is taking courses), provides the basis for tuition charges. Ph.D. students should consult the bulletin for the Graduate School of Arts and Sciences.

COMPREHENSIVE FEE/ MATRICULATION AND FACILITIES

Eng.Sc.D. candidates engaged only in research, and who have completed their twelve (12) credits of Doctoral Research Instruction (see "The Graduate Programs" in this bulletin), are assessed a Comprehensive Fee of \$2,006 per term by The Fu Foundation School of Engineering and Applied Science.

Ph.D. candidates engaged only in research are assessed \$2,006 per term for Matriculation and Facilities by the Graduate School of Arts and Sciences.

MANDATORY FEES

University facilities fee:

- Full-time master's programs: \$498 per term
- All other full-time programs: \$461 per term

Health Service fee: \$510 per term

International Services charge:
\$70 per term (international students only)

Transcript fee: \$105 (one-time charge)

OTHER FEES

Activities fees:

- Full-time master's program: \$100
- Part-time master's program: \$50

Application and late fees:

- Application for graduate admission: \$85
- Late registration fee:
 - during late registration: \$50
 - after late registration: \$100

Books and course materials:

Depends upon course

Laboratory fees: See course listings

IEOR master's program fee:

- Full-time master's program: \$1,000
- Part-time master's program: \$500

HEALTH INSURANCE

Columbia University offers the Student Medical Insurance Plan, which provides both Basic and Comprehensive levels of coverage. Full-time students are automatically enrolled in the Basic level of the Plan and billed for the insurance premium in addition to the Health Service fee. Visit the Columbia Health website at health.columbia.edu for detailed information about medical insurance coverage options and directions for making

confirmation, enrollment, or waiver requests.

PERSONAL EXPENSES

Students should expect to incur miscellaneous personal expenses for such items as food, clothing, linen, laundry, dry cleaning, and so forth.

The University advises students to open a local bank account upon arrival in New York City. Since it often takes as long as three weeks for the first deposit to clear, students should plan to cover immediate expenses using either a credit card, traveler's checks, or cash draft drawn on a local bank. Students are urged not to arrive in New York without sufficient start-up funds.

LABORATORY CHARGES

Students may need to add another \$100 to \$300 for drafting materials or laboratory fees in certain courses. Each student taking laboratory courses must furnish, at his or her own expense, the necessary notebooks, blank forms, and similar supplies. In some laboratory courses, a fee is charged to cover expendable materials and equipment maintenance; the amount of the fee is shown with the descriptions in the course listings. Students engaged in special tests, investigations, theses, or research work are required to meet the costs of expendable materials as may be necessary for this work and in accordance with such arrangements as may be made between the student and the department immediately concerned.

DAMAGES

All students will be charged for damage to instruments or apparatus caused by their carelessness. The amount of the charge will be the actual cost of repair, and, if the damage results in total loss of the apparatus, adjustment will be made in the charge for age or condition. To ensure that there may be no question as to the liability for damage, students should note whether the apparatus is in good condition before use and, in case of difficulty, request instruction in its proper operation. Where there is

danger of costly damage, an instructor should be requested to inspect the apparatus. Liability for breakage will be decided by the instructor in charge of the course.

When the laboratory work is done by a group, charges for breakage will be divided among the members of the group. The students responsible for any damage will be notified that a charge is being made against them. The amount of the charge will be stated at that time or as soon as it can be determined.

TUITION AND FEE REFUNDS

Students who make a complete withdrawal from a term are assessed a withdrawal fee of \$75. Late fees, application fees, withdrawal fees, tuition deposits, special fees, computer fees, special examination fees, and transcript fees are not refundable.

The Health Service Fee, Health Insurance Premium, University facilities fees, and student activity fees are not refundable after the change of program period.

Students who withdraw within the first 60 percent of the academic period are subject to a *pro rata* refund calculation, which refunds a portion of tuition based on the percentage of the term remaining after the time of withdrawal. This calculation is made from the date the student's written notice of withdrawal is received by the Office of Graduate Student Affairs.

Percentage Refund for Withdrawal during First Nine Weeks of Term

Prorated for calendars of a different duration, if the entire program is dropped:

1st week	100%
2nd week	100%
3rd week	90%
4th week	80%
5th week	70%
6th week	60%
7th week	50%
8th week	40%
9th week and after	0%

Refund Policy When Dropping Individual Courses

Tuition for courses dropped by the

last day of the Change-of-Program period is refunded in full. There is no refund of tuition for individual courses dropped after the last day of the Change-of-Program period. The Change-of-Program period is usually the first two weeks of the fall or spring semesters (please note that the first week of the semester usually begins on a Tuesday).

Please note: The prorated schedule above does not pertain to individual classes dropped (unless your entire schedule consists of only one class). The prorated schedule pertains to withdrawals. Withdrawal is defined as dropping one's entire program.

For students receiving federal student aid, refunds will be made to the federal aid programs in accordance with Department of Education regulations. Refunds will be credited in the following order:

- Federal Unsubsidized Stafford Loans
- Federal Stafford Loans
- Federal Perkins Loans
- Federal PLUS Loans (when disbursed through the University)
- Federal Pell Grants
- Federal Supplemental Educational Opportunity Grants
- Other Title IV funds

Withdrawing students should be aware that they will not be entitled to any portion of a refund until all Title IV programs are credited and all outstanding charges have been paid.

FINANCING GRADUATE EDUCATION

The academic departments of Columbia Engineering and the Office of Financial Aid and Educational Financing seek to ensure that all academically qualified students have enough financial support to enable them to work toward their degree. Possible forms of support for tuition, fees, books, and living expenses are: institutional grants, fellowships, teaching and research assistantships, on- or off-campus employment, and student loans. The Office of Financial Aid and Educational Financing assists students with developing financing plans for completing a degree.

Columbia University graduate funds are administered by two separate branches of the University, and the application materials required by the two branches differ. Institutional grants, fellowships, and teaching and research assistantships are all departmentally-administered funds. Questions regarding these awards should be directed to your academic department. Federal Student Loans (Unsubsidized, Graduate PLUS, and Perkins) and private student loans are administered by the Office of Financial Aid and Educational Financing. Questions about loans should be directed to the financial aid office.

INSTRUCTIONS FOR FINANCIAL AID APPLICANTS

Deadlines

Apply for financial aid at the same time that you apply for admission. Your admissions application must be received by the December 15 deadline to be eligible for The Fu Foundation School of Engineering and Applied Science departmental funding (institutional grants, fellowships, and teaching and research assistantships). Spring admissions applicants will not be considered for departmental funding.

Incoming applicants and continuing students should complete the FAFSA by May 5 for fall enrollment.

Guidelines for continuing students are available from departmental advisers in advance of the established deadline. All continuing supported students must preregister for classes during the preregistration period.

GRADUATE SCHOOL DEPARTMENTAL FUNDING

The graduate departments of Columbia Engineering offer an extensive array of funding. Funding decisions, based solely on merit, and contingent upon making satisfactory academic progress, are made by the departments. All applicants for admission and continuing students maintaining satisfactory academic standing will be considered for departmental funds. Applicants should contact their department directly for information. Columbia Engineering

prospective and continuing graduate students must complete their FAFSA in order to be considered for all forms of graduate financing (both departmentally-administered and financial aid-administered funds). The application for admission to Columbia Engineering graduate programs is also used to apply for departmental funding. Outside scholarships for which you qualify must be reported to your department and the Office of Financial Aid and Educational Financing. The School reserves the right to adjust your institutional award if you hold an outside scholarship, fellowship, or other outside funding.

Institutional Grants

Institutional grants are awarded to graduate students on the basis of academic merit. Recipients must maintain satisfactory academic standing.

Fellowships

Fellowships are financial and intellectual awards for academic merit that provide stipends to be used by fellows to further their research. If you are awarded a fellowship, you are expected to devote time to your own work, and you are not required to render any service to the University or donor. You may publish research produced by your fellowship work. As a fellow, you may not engage in remunerative employment without consent of the Dean. Applicants should contact the department directly for information. See the complete listing of fellowships on pages 228–230.

Assistantships

Teaching and research assistantships, available to doctoral students in all departments, provide tuition exemption and a living stipend. Duties may include teaching, laboratory supervision, participation in faculty research, and other related activities. Teaching and research assistantships require up to twenty hours of work per week. If you are participating in faculty research that fulfills degree requirements, you may apply for a research assistantship. Assistantships are awarded on the basis of academic merit.

ALTERNATIVE FUNDING SOURCES

External Awards

Because it is not possible to offer full grant and fellowship support to all graduate students and because of the prestige inherent in holding an award through open competition, applicants are encouraged to consider major national and international fellowship opportunities. It is important that prospective graduate students explore every available source of funding for graduate study.

In researching outside funding you may look to faculty advisers, career services offices, deans of students, and offices of financial aid where frequently you may find resource materials, books, and grant applications for a wide variety of funding sources. You must notify both your Columbia Engineering academic department and the Office of Financial Aid and Educational Financing of any outside awards that you will be receiving.

Funding for International Students

To secure a visa, international students must demonstrate that they have sufficient funding to complete the degree. Many international students obtain support for their educational expenses from their government, a foundation, or a private agency.

International students who apply to doctoral programs of study by the December 15 deadline and are admitted

to a Columbia Engineering doctoral program are automatically considered for departmental funding (institutional grants, fellowships, and teaching and research assistantships, upon completion of the required financial aid forms referred to above. Spring admissions applicants will not be considered for departmental funding. Continuing international students must preregister for classes during the preregistration period and complete an enrollment status form to be considered for departmental funding.

Most private student loan programs are restricted to U.S. citizens and permanent residents. However, international students may be eligible to apply for these domestic loan programs with a creditworthy cosigner who is a citizen or permanent resident in the United States. Depending on the loan program, you may need a valid U.S. Social Security number.

Students who study at Columbia Engineering on temporary visas should fully understand the regulations concerning possible employment under those visas. Before making plans for employment in the United States, international students should consult with the International Students and Scholars Office (ISSO), located at 524 Riverside Drive, Suite 200; 212-854-3587. Its website is columbia.edu/cu/isso.

OTHER FINANCIAL AID—FEDERAL AND PRIVATE PROGRAMS

U.S. citizens and permanent residents enrolled at least half-time in a degree-granting program are eligible to apply for federal student loans. To apply for federal student loans, students should complete the Free Application for Federal Student Aid (FAFSA) using Columbia University's school code 002707 by May 5 for fall enrollment

Several private student loan programs are available to both U.S. citizens and international students. These loans require that you have a good credit standing. International students may be eligible for a private loan with a creditworthy U.S. citizen or permanent resident cosigner.

Detailed information and application instructions for student loans may be found at the Office of Financial Aid and Educational Financing website at cc-seas.financialaid.columbia.edu/content/graduate-engineering-aid.

Determination of your eligibility for financial aid is based in part on the number of courses for which you register. If you enroll in fewer courses than you initially reported on the loan request form, your loan eligibility may be reduced.

The FAFSA and the online loan request form must be completed each academic year, and you must maintain satisfactory academic progress as defined in "The Graduate Programs" section in order to remain eligible for federal student loans.

VETERAN'S BENEFITS

Various Department of Veterans Affairs programs provide educational benefits for sons, daughters, and spouses of deceased or permanently disabled veterans as well as for veterans and in-service personnel who served on active duty in the U.S. Armed Forces after January 1, 1955. In these programs the amount of benefits varies. Under most programs the student pays tuition and fees at the time of registration but receives a monthly allowance from Veterans Affairs.

Since interpretation of regulations governing veterans' benefits is subject to change, veterans and their dependents should keep in touch with the Department of Veterans Affairs. For additional information and assistance in completing the necessary forms, contact 1-800-827-1000, or consult their website (www.va.gov).

Detailed information regarding the veteran population at Columbia and policies including the Veteran's Readmission Provision may be found on the Veterans Affairs website (veteranaffairs.columbia.edu).

EMPLOYMENT

Students on fellowship support must obtain the permission of the Dean before accepting remunerative employment.



Students who study at Columbia Engineering on temporary visas should fully understand the regulations concerning possible employment under those visas. Before making plans for employment in the United States, international students should consult with the International Students and Scholars Office (ISSO) located at 524 Riverside Drive, Suite 200; 212-854-3587. Its website is columbia.edu/cu/isso.

On-Campus Employment

The Center for Career Education maintains an extensive listing of student employment opportunities. The Center for Career Education (CCE) is located at East Campus, Lower Level, 212-854-5609, careereducation.columbia.edu.

Off-Campus Employment in New York City

One of the nation's largest urban areas, the city offers a wide variety of opportunities for part-time work. Many students gain significant experience in fields related to their research and study while they meet a portion of their educational expenses.

CONTACT INFORMATION

For questions about institutional grants, fellowships, and teaching and research assistantships, contact your academic department.

For questions about on- or off-campus non-need-based employment, contact the Center for Career Education, located at East

Campus, Lower Level, 212-854-5609, careereducation.columbia.edu.

For questions about student loans, contact:
Office of Financial Aid and Educational Financing
618 Lerner Hall
Mailing: 100 Hamilton Hall
1130 Amsterdam Avenue, MC 2802
New York, NY 10027

Phone: 212-854-3711

Fax: 212-854-5353

E-mail: gradseas-finaid@columbia.edu
cc-seas.financialaid.columbia.edu/content/graduate-engineering-aid.