COLUMBIA | ENGINEERING
The Fu Foundation School of Engineering and Applied Science

STUDENT RESEARCH INVOLVEMENT PROGRAM

2015–2016

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Introduction

At The Fu Foundation School of Engineering and Applied Science at Columbia University, the faculty takes an active role in research, which is funded by both private and government sources. Faculty members view student involvement in research as a part of the educational process and actively encourage it.

Many students at Columbia Engineering are destined for the professional research environment, while others may work in professional capacities in tandem with the research function. It is the purpose of the program and this guide to enable undergraduate students to participate.

Participation in the program is voluntary, although students are advised that the faculty expect students to honor any commitment they may make. This booklet, also available online at engineering.columbia.edu/student-research-involvement-program, is designed to describe the specific opportunities themselves and to lay out the routes of access.

How to Use This Publication

Columbia Engineering faculty members have been asked to list general topics or projects that may become specific research opportunities for undergraduate students. This booklet is a compilation of their responses. For more detailed information on specific research opportunities, please visit engineering.columbia.edu/opportunities.

A "research opportunity" is similar to—but not quite the same as—a job in research. Some opportunities involve academic credit and require that students register for "independent study" courses. Some positions involve pay, either as a part-time, casual employee of the University, or as a participant in the Federal Work-Study Program. Thus, special work-study eligibility via the Financial Aid Office may be required. Some opportunities extend for one or more academic terms; others continue over the summer. Some may begin only at the start of an academic year, in September. Opportunities may entail different time commitments or time periods of participation. Normally, students are expected to have an overall grade point average of at least 3.0.

The duration and other critical factors of the opportunity reflect the needs of the faculty research coordinator and the skills, interests, and capacities of the student participants. As a student grasps new aspects of a project, such as by learning new skills, his/her role in the project may grow and evolve.

Each research opportunity involves areas of expertise and specialization. Thus, the opportunities have been listed both in terms of (1) the specific research area and (2) the special skills required of the student. Each faculty member in charge of a research area (the "contact") was asked to specify whether his/her opportunity involved any or all of the following research activities:

- paper study, mathematical projects, library research
- engineering or scientific design
- mechanical or electrical assembly
- computational or computer analysis

They were also asked to specify:

- whether the opportunity entailed academic credit or hourly wages (either through the Federal Work-Study Program or other remuneration)
- the possible duration, whether term-time or summer participation only
- the weekly hour commitment
- any individual qualifications desirable in the applicant, such as minimum GPA, required courses, prior work experience, and computer language fluency

In some cases, respondents did not specify a certain item of information. This omission indicates that the item is not likely to be a requisite or constraint.

Application Procedure

If you are interested in participating in direct research, your first step is to read through the opportunity descriptions on the following pages or to check for current opportunities via the online SRIP portal at http://portal.seas.columbia.edu/research/student.php/position. Research opportunities are listed in order of posting date but can be filtered by keyword or by department. Identify the two or three opportunities that interest you the most, and ask yourself whether or not you meet the basic qualifications. Remember, it is likely that you will not be the only applicant for a specific opportunity in the Student Research Involvement Program; inquiring about more than one opportunity is a prudent strategy.

Department of Applied Physics and Applied Mathematics

Chair: Professor I. Cevdet Noyan, 200 Mudd, 212-854-4457
apam.columbia.edu

Opportunities

- creation of novel atomic-scale magnetic materials
- measurement of ultrafast (~100 ps) magnetization dynamics
- measurement of magnetization and magneto-transport properties
- computer simulation of physical properties of materials

Opportunities could include laboratory, literature, or computational work. Projects can be tailored to the strengths and/or interests of the student. Enthusiasm and self-motivation are a plus. Academic credit may be available. Minimum 8 hours per week commitment is required.

Contact: Professor William Bailey, web54@columbia.edu, 1140 Mudd, 212-854-3090

Opportunities

- structure and properties of nanoparticles
- x-ray and neutron scattering experiments on complex materials with applications from energy to pharmaceuticals
- simulation and modeling of nanoparticle structures
- scientific software development
- web development of educational website

Opportunities for motivated sophomore, junior, and senior students, for academic credit, to participate in the full range of research activities. Experiments are done at National Laboratories (Brookhaven, Argonne, Los Alamos) with opportunities for undergrads to participate. Various possibilities exist depending on the interests of the students, though most involve some use of computers: either data analysis using existing programs or developing new analyses by writing new programs. Students with expertise and an interest in Python programming are especially welcome for numerous scientific software development activities, and also php/SQL for an education website project. Minimum commitment of 8 hours per week is required.

Contact: Professor Simon J. L. Billinge, sb2896@columbia.edu, 1105 Mudd, 212-854-2918

Opportunities

- synthesis of oxide nanoparticles
- measuring their intrinsic properties such as elastic modulus and bond length as a function of crystal-size; thermodynamic redox analysis of the oxides; microstructures
- interfaces and grain boundaries
- high temperature superconducting cuprates, their microstructure engineering, and boundary engineering for >20 Tesla applications

Opportunities include paper study, nanoparticle synthesis, mechanical and electrical assembly, and computational analysis, and may be done in exchange for academic credit; work-study and summer participation are encouraged. Students should have experience with lab tools and instruments. Weekly commitment of 8 hours required, as is completion of *MSAE E3103: Elements of materials science.*

Contact: Professor Siu-Wai Chan, sc174@columbia.edu, 1136 Mudd, 212-854-8519

Opportunities

- computational mathematics and multiscale modeling

Opportunities include a range of activities: literature research, paper study, mathematical modeling, and numerical simulations. Topics range from the study of mathematical models and algorithmic development to applications in data and image science, materials science and biological science. Requires a basic knowledge of calculus, linear algebra, differential equations, and computer programming skills.

Contact: Professor Qiang Du, qd2125@columbia.edu, 284A Eng Terrace, 212-854-8139

Opportunities

- nanocrystals, nanoscience, and nanotechnology
- laser probe of thin films and thin film processing
- fabrication and properties of nanomaterials

Opportunities for motivated sophomore, junior, and senior students who are willing to commit to at least 6 hours per week, for academic credit or possible remuneration, to participate in the full range of research activities: paper study, mathematical projects, library research, engineering or scientific design, mechanical or electrical assembly, and computational or computer analysis.

Contact: Professor Irving P. Herman, iph1@columbia.edu, 905 CEPSR, 212-854-4950

Opportunities

- computational methods for modeling coastal hazards such as storm surge and tsunamis
- computational efficiency, stability, and accuracy of the methods employed
- modeling of shallow-mass-flows such as landslides, pyroclastic flows, and rip-currents

A number of projects are available to undergraduate students depending on their interests and skills. Projects range from work on particular events such as Hurricane Sandy, visualization of such events, and investigation of the computational issues of the underlying algorithms. Projects will all include some amount of programming, so knowledge in at least one language is important. Academic credit is available depending on the project, but a minimum commitment of time is required.

Contact: Professor Kyle Mandli, kyle.mandli@columbia.edu, 288 Eng Terrace, 212-854-4485

Opportunities

- applied electrodynamics
- plasma physics and experiments
- space physics, microwave heating, and plasma sources

Opportunities for student research in the measurement, control, and simulation of high-temperature, bright matter found in space and in controlled laboratory experiments. Projects include activities in computational physics, visualization and analysis of measurements, and design and assembly of physics experiments. Preference will be given to students interested in the physics of high temperature ionized matter and capable of understanding applied electrodynamics. Both academic credit and remunerative positions available. The desired weekly commitment is at least 5 hours. Prerequisite: *APPH E3300: Applied electromagnetism* or equivalent.

Contact: Professor Michael Mauel, mem4@columbia.edu, 213 Mudd, 212-854-4455

Opportunities

- applied electrodynamics
- plasma physics and experiments

Opportunities include the following activities: mathematical projects, library research, design and assembly, and computer analysis. Preference will be given to students interested in and capable of laboratory work. Both academic credit and remunerative positions available. The desired weekly commitment is at least 5 hours. Desired prerequisite: *APPH E3300: Applied electromagnetism* or equivalent.

Contact: Professor Gerald Navratil, navratil@columbia.edu, 209 Mudd, 212-854-4496

Opportunities

- mechanical response of small domains such as on-chip structures in microelectronics
- measurement of stress and strain in engineering components in all size scales
- analytical and numerical modeling of the mechanical response of thin films and nanostructures

Possibility of working in the National Laboratories (Los Alamos, Argonne, Lawrence Berkeley, and Brookhaven) for short periods of time during breaks. Projects can be tailored to the strengths and/or interests of the student. Enthusiasm and self-motivation are requirements. Academic credit may be available. Minimum commitment of 8 hours per week is required.

Contact: Professor I. Cevdet Noyan, icn2@columbia.edu, 1120 Mudd, 212-854-8919

Opportunities

- electron fluids in semiconductors
- condensed matter at very low temperatures
- artificial lattices in semiconductors

Opportunities for undergraduates interested in fundamental science in semiconductors. The topics of interest include quantum liquids of electrons in superior quality quantum structures, nanoprocessing of semiconductors, and design and fabrications of novel structures at the nanoscale. Interested students are expected to study the key topics and to participate in the laboratory work. Minimum expected commitment is 8 hours per week.

Contact: Professor Aron Pinczuk, ap359@columbia.edu, 919 CEPSR, 212-854-9632

Opportunities

- computational physics and mathematics

A commitment of no less than 8 hours per week is expected. Knowledge of C, C++, Python/MATLAB, and UNIX is essential.

Contact: Professor Marc Spiegelman, mspieg@ldeo.columbia.edu, 211 Mudd, 212-854-4918

Opportunities

- experimental nanoscience
- nanoscience tool development
- synthesis of new materials

Opportunities for juniors and seniors to participate in research focusing on understanding physics and chemistry at the single molecule level. Experimental work will involve using and developing improvements to an atomic force microscope or scanning tunneling microscope.

Students willing to commit to at least 8 hours per week, for academic credit and/or possible wages, should apply. Successful research may extend into the summer. Previous employment, computational literacy, and basic knowledge of chemistry would be highly useful.

Contact: Professor Latha Venkataraman, lv2117@columbia.edu, 212-854-1786

Opportunities

- metamaterials
- microwave heating
- plasma physics

Motivated, enthusiastic juniors and seniors will have the opportunity to (1) participate in experiments and related activities on the CIRCUS and CNT devices for the magnetic confinement of plasmas; and (2) design, model, microfabricate, and optically test innovative metamaterial lenses for microwave applications. Both academic credit and remunerative positions are available in the academic year as well as during the summer. Weekly commitment: at least 10 hours. Prerequisite: *APPH E3300: Applied electromagnetism* or equivalent. Highly desirable: previous lab experience; computer literacy (two or more of the following: COMSOL, CST, Fortran 90, IDL, Mathematica, MATLAB, Python, SolidWorks).

Contact: Professor Francesco Volpe, fvolpe@columbia.edu, 204 Mudd, 212-854-6528, pl.apam.columbia.edu

Opportunities

- applied mathematics
- wave phenomena in fundamental and applied science

Opportunities for motivated juniors and seniors to participate in a range of activities: library research, paper study, computer simulation, mathematical projects (modeling and analysis). Skills in computer programming would be very useful (e.g., MATLAB), as would basic knowledge of differential equations, dynamical systems, linear algebra, and analysis. A commitment of at least 8 hours per week is required.

Contact: Professor Michael I. Weinstein, miw2103@columbia.edu, 212 Mudd, 212-854-3624

Opportunities

- machine learning
- biological networks
- systems biology
- computer vision and image analysis

Focus areas include applications of machine learning, statistical inference, and information theory for the inference, analysis, simulation, and organization of biological networks. Students of all years willing to commit to at least 6 hours per week, for academic credit and/or possible wages, should apply. Successful research may extend into the summer. Previous employment, computational literacy (particularly UNIX, MATLAB, Python), and/or mathematical literacy (differential equations, dynamical systems, linear algebra, and/or numerical analysis) would be highly useful.

Contact: Professor Chris Wiggins, chris.wiggins@columbia.edu, 205 Mudd, 212-854-1114

Department of Biomedical Engineering

Chair: Andrew Laine, 351 Eng Terrace, 212-854-6539
bme.columbia.edu

Opportunities

- synthetic biology
- design and engineering of bacteria for cancer detection and therapy
- microfluidic devices for long-term monitoring of gene expression dynamics
- experiments on mouse disease models (cancer, microbiome, etc.)
- computational modeling of gene circuits
- microbial environmental sensors

Our laboratory works on understanding and engineering microbes to build novel applications for the environment and human health. The two main focuses are to (1) understand the dynamics of small gene networks in native biological systems; and (2) engineer gene circuits for applications in cancer, microbiomes, and environmental monitoring. Possible projects include engineering bacterial strains, design and fabrication of microfluidic systems for mammalian and bacterial monitoring, and *in vivo* imaging of bacteria in mouse disease models. Possible credit or remuneration, 12 hours per week term-time and full time during the summer.

Contact: Professor Tal Danino, taldanino@gmail.com, Northwest Corner

Opportunities

- image analysis and modeling of bone microstructure
- biomedical analysis and computational biomechanics of clinical images
- microcontact printing and bone cell network in mechanotransduction
- 3D single cell mechanics

Opportunities for undergraduate research assistants working on various projects in the laboratory: image analysis and modeling of bone microstructure using micro-computed tomography; biomedical image analysis and computational biomechanics of patients' images; microcontact printing technology, bone cell network and mechanotransduction, single cell 3D biomechanics and real-time signal transduction. Students seeking long-term association are preferred. Possible credit or remuneration, 12 hours per week during the academic year and full time during the summer.

Contact: Professor X. Edward Guo, exg1@columbia.edu, 351 Eng Terrace, 212-854-6196

Opportunities

- nanobiotechnology
- engineering applications of molecular motors
- synthetic biology using minimal proteinaceous systems
- science and engineering of nonfouling surfaces

The laboratory pursues engineering at the molecular scale, in particular the design of active nanosystems incorporating biomolecular motors and other enzymes, the study of active self-assembly, and the investigation of protein-resistant polymer coatings. Possible credit or remuneration, 12 hours per week term-time and full time during the summer. Potential summer research project in international partner laboratories.

Contact: Professor Henry Hess, hh2374@columbia.edu, 351 Eng Terrace, 212-854-7749

Opportunities

- biophotonics
- design and testing of instrumentation for optical medical imaging
- software development for medical image reconstruction
- participate in clinical studies on breast cancer, peripheral vascular disease, and others

This laboratory works toward a novel medical imaging modality in which near-infrared light is used to obtain cross-sectional images of various body parts, such as the breast, brain, or limbs. Possible projects include a wide range of topics such as studying light-tissue interactions, setting up clusters for parallel processing, numerically solving large-scale optimization problems with finite-difference and finite-element schemes, designing electro-optical circuits for light amplification and detection, and performing clinical studies concerning rheumatoid arthritis, peripheral vascular disease, breast cancer, and others. Possible credit or remuneration, 12 hours per week term-time and full time during the summer.

Contact: Professor Andreas H. Hielscher, ahh2004@columbia.edu, 351 Eng Terrace, 212-854-5080

Opportunities

- *in vivo* optical imaging and microscopy
- development of laser imaging and CCD camera–based systems
- acquisition of *in vivo* data to investigate neurovascular coupling in the brain
- electrical propagation in the heart, and skin cancer
- data analysis and reconstruction of dynamic optical imaging and microscopy data

Undergraduates joining our lab learn about different high-resolution optical imaging methods. We apply these methods primarily to study the function of the brain *in vivo,* but also have projects relating to dermal and cardiac imaging. Students may wish to gain experience developing imaging systems, applying and learning electronics, optics, data acquisition hardware, and graphical user interface software development. Students may also wish to learn to acquire *in vivo* data and investigate some of the fundamental aspects of brain function such as neurovascular coupling—the way that neurons in the brain communicate with the blood supply. Image processing, computer simulations, and data processing are also major aspects of our work to which students can contribute. Possible credit or remuneration, 12 hours per week term-time and full time during the summer.

Contact: Professor Elizabeth Hillman, eh2245@columbia.edu, 406 CEPSR, 212-854-2788

Opportunities

- culturing of cell-seeded three-dimensional scaffolds for orthopedic tissue engineering
- evaluation of functional material/biochemical properties of growing tissue constructs
- studies of orthopedic mechanotransduction-cell response to mechanical forces

Students are involved with multidisciplinary research of the Cellular Engineering Laboratory that is aimed at the study of physical regulation of articular cartilage as well as orthopedic tissue engineering. Students seeking long-term associations are preferred. Possible credit or remuneration, 12 hours per week term-time and full time during the summer.

Contact: Professor Clark T. Hung, cth6@columbia.edu, 351 Eng Terrace, 212-854-6542

Opportunities

- *in vitro* cell culture and molecular biology applied to understanding how bone cells sense and respond to mechanical signals
- evaluation of the response of cells expressing mutant mechanosensing proteins
- microscopic determination of the mechanical behavior of cells
- *in vivo* evaluation of the skeletal response to mechanical loads of mutant mice

The Cell and Molecular Biomechanics Laboratory is focused on determining the molecular mechanism that bone cells use to sense and respond to changes in their mechanical environment. Opportunities for undergraduate research assistants include utilizing techniques from cell and molecular biology to determine the role of specific proteins in mechanosensing. These insights are translated into *in vivo* mouse models with mutations of specific proteins that are, in turn, evaluated in terms of the ability of their bone to adapt to changes in the mechanical demands they are exposed to. Possible credit or remuneration, 12 hours per week during the academic year and full time during the summer.

Contact: Professor Christopher R. Jacobs, crj2111@columbia.edu, 351 Eng Terrace, 212-851-0271

Opportunities

- micro- and nanoscale fabrication of biological systems
- immune engineering
- cell signaling

Contemporary fabrication techniques offer new ways to answer questions in cell signaling and to engineer cell function. Undergraduates will have the opportunity to develop these techniques and apply them to cellular and molecular systems. Skills include microfabrication, protein design and production, advanced fluorescence microscopy, and cell culture. Undergraduates will have the opportunity to learn these skills, and must bring enthusiasm and creativity to these projects. We are particularly interested in students seeking significant, multisemester projects.

Contact: Professor Lance C. Kam, lk2141@columbia.edu, 363 Eng Terrace, 212-854-8611

Opportunities

- medical image analysis: quantification
- 3D cardiac ultrasound imaging: dynamic segmentation
- methods for automated recognition of protein crystals
- nodule detection algorithms in spiral CT lung screening
- longitudinal analysis of medical images and health records
- MRI cardiac tagging for strain measures

Students are sought who are interested in assisting in the testing, performance evaluation, and development of quantitative and qualitative methods of image analysis. Projects include the detection and diagnosis of disease through the modalities of ultrasound, MRI, PET, CT, and digital mammography. Participation requires competence of programming in MATLAB, C, IDL, or Java and an interest in learning underlying algorithms. Students with knowledge of signal processing and applied mathematics are preferred. Projects can provide academic credit and remuneration, 8–12 hours per week during the academic year and full-time opportunities in the summer.

Contact: Professor Andrew Laine, laine@columbia.edu, 351 Eng Terrace, 212-854-6539

Opportunities

- development of novel biomaterials for musculoskeletal tissue regeneration
- study of interactions between cells and biomaterial surfaces
- dental tissue engineering
- research projects: design and custom-built small devices, literature search

Student participants are introduced to various stages of the development of tissue-engineered scaffolds and hybrid matrices for musculoskeletal and dental tissue engineering, focusing on applications at the interface between bone and soft tissue. The student may be involved in the background literature search, in the design of experiments, as well as in data analysis, modeling, and interpretation. An interest in biomaterial design and/or cell-material interaction is expected. Possible credit or work study, 10–12 hours per week term-time or full time during the summer.

Contact: Professor Helen H. Lu, hhlu@columbia.edu, 351 Eng Terrace, 212-854-4071

Opportunities

- researching the molecular pathophysiology of traumatic brain injury
- development of the necessary instrumentation to simulate brain injury
- tissue culture of rat brain tissue
- electrophysiological measurements and signal processing
- studying brain injury biomechanics

Matriculating students with a minimum 3.0 GPA are invited to apply for research opportunities to explore the molecular, cellular, and functional consequences of traumatic brain injury. These opportunities span the full gamut of projects from instrumentation development and assembly, feedback control systems, image analysis, signal processing, tissue culture, application of biomechanics, etc. Experience in any of the above-mentioned fields is beneficial but not a prerequisite; however, an enthusiasm to reduce the societal impact of head injury is required. Students seeking long-term associations are preferred. Possible credit or remuneration, 12 hours per week term-time and full time during the summer.

Contact: Professor Barclay Morrison, bm2119@columbia.edu, 363 Eng Terrace, 212-854-6277

Opportunities

- neurocomputational modeling of visual cortex
- computational vision
- analysis of spatiotemporal and spectral imagery

Student participants are involved in development and evaluation of biomimetic models of perceptual organization and object recognition. An interest in learning-related aspects of neuroscience and computer vision is expected. Good programming skills required (e.g., MATLAB, C, C++, Java). Background in linear algebra and introduction to probability theory would also be helpful (but not required). Possible credit or remuneration, 12 hours per week term-time and full time during the summer.

Contact: Professor Paul Sajda, ps629@columbia.edu, 404 CEPSR, 212-854-5279

Opportunities

- MEMS devices to improve the health of people in developing countries
- microscale tissue engineering

Undergraduate students work closely with a graduate student on an independent project. Our laboratory has two areas of focus: (1) developing new low-cost and portable diagnostic devices to improve global health (such as protein sensors); and (2) using molecular and microtechnology-based approaches to study and control how tissues form (such as blood vessels, including work with stem cells). Possible credit or remuneration, with a commitment of 10 hours per week term-time and full time during the summer.

Contact: Professor Samuel Sia, ss2735@columbia.edu, 363 Eng Terrace

Opportunities

- tissue engineering of human grafts
- studies of human stem cells
- advanced biomaterials and bioreactors
- modeling of disease

Opportunities for undergraduate research assistants to work on biophysical regulation of adult human stem cells (mesenchymal, iPS), tissue engineering of functional grafts (heart, cartilage, bone, lung). Both experimental and modeling studies are available. Laboratory skills and experience with cell culture are a great plus. Work for credit during the semester. The weekly commitment is 10 hours or more.

Contact: Professor Gordana Vunjak-Novakovic, gv2131@columbia.edu,
622 West 168th Street (Vanderbilt Clinic), Room 12-234, 212-305-2304

Opportunities

- neural coding in the somatosensory pathway
- behavioral training of rodents
- multisensory integration in rodents and human subjects
- analysis of seizure propagation in the brain

Opportunities for undergraduate research assistants working on various projects in the Laboratory for Neural Engineering and Control: neural coding in the somatosensory pathway, multisensory integration in rodent and human subjects, behavioral training of rodents, and analysis of seizure propagation in the brain. Students seeking long-term association are preferred. Possible credit or remuneration, 15 hours per week during the academic year and full time during the summer.

Contact: Professor Qi Wang, qi.wang@columbia.edu, 351 Eng Terrace, 212-854-3657

Department of Chemical Engineering

Chair: Professor Sanat K. Kumar, 801 Mudd, 212-854-4453
cheme.columbia.edu

Opportunities

- engineering of protein molecules using recombinant DNA technology
- protein purification and protein analysis
- engineering of metabolic networks

Research in this laboratory involves experimental studies in protein engineering. Molecular biology tools and techniques are used, including genetic engineering, electrophoresis, chromatography, and assay development. Academic credit and work study are available. Students should be prepared to commit at least 8 hours per week in exchange for academic credit.

Contact: Professor Scott Banta, sbanta@columbia.edu, 820 Mudd, 212-854-7531

Opportunities

- advanced materials research: behavior of macromolecules in solution; adsorption and self-assembly of macromolecules and nanoparticles; characterization of materials for pharmaceutical applications

These projects all involve experimental studies and require at least 6 hours per week commitment. Opportunities are available to study new/unique synthetic materials, mainly macromolecular (i.e., polymeric), for potential applications as advanced coatings, sensors, and thin films. Other projects address characterizing materials used in drug manufacture, packaging, and delivery. Participants learn experimental methods and are responsible for systematic application of the methods, data reduction, and reporting of results. Projects can be undertaken for academic credit or may involve sponsored internships.

- computing: computer simulation of molecular systems; data analysis; software development; web page development

Projects are available to exploit computing skills for materials research, teaching, or Internet applications. Participants normally enroll for academic credit, but work study and internships may be available. Familiarity with Windows- and/or UNIX-based operating systems is necessary, and depending on the project, knowledge of computing languages/software packages (e.g., Fortran, C, Mathcad, IDL) and/or web-development tools (e.g., HTML) is also necessary.

Contact: Professor Chris Durning, cjd2@columbia.edu, 801 Mudd, 212-854-8161

Opportunities

- nanoparticle-polymer hybrids-matrix free nanocomposites
- magnetic nanoparticles for drug delivery
- solid phase synthesis of branched polymers-surface modification
- kinetics of polymer interfacial reactions

These activities include experimental laboratory work such as polymer synthesis, analysis of soft material surfaces and properties, construction of novel instrumentation for characterizing polymeric materials, as well as some theoretical calculations of polymer properties. Students should be prepared to commit 6–8 hours per week to attain academic credit.

Contact: Professor Jeff Koberstein, jk1191@columbia.edu, 801 Mudd, 212-854-3120

Opportunities

- study of transport phenomena in microfluidic flows, mostly biological
- application of physical principles and quantitative modeling to the understanding of morphogenesis in embryos

The laboratory can host three undergraduate students at most at any one time; students seeking long-term associations are preferred. The first opportunity involves closely connected experimental and modeling work associated with microfluidics, including its application to the development of blood-processing devices and related fundamental issues of cell and protein behavior in micromechanical environments. The second opportunity involves a long-term effort to understand how multicellular organisms achieve their characteristic morphology, especially the complex morphology of the mammalian kidney. Any academic credit and/or wages are normally available only after a probationary period that may be as long as an academic year. The weekly time commitment must be at least 10 hours. Students must have a GPA of 3.3 or higher and some record of previous employment or laboratory experience.

Contact: Professor Edward Leonard, leonard@columbia.edu, 812 Mudd, 212-854-4448 (laboratory: 1033 Mudd, 212-854-3007)

Opportunities

- atmospheric chemistry and physics
- air pollution
- climate

Research in this laboratory involves experimental and modeling studies in atmospheric chemistry and climate. Opportunities exist for independent projects or projects in support of doctoral research. Students should be prepared to commit at least 8 hours per week. Academic credit and work study are available.

Contact: Professor V. Faye McNeill, vfm2103@columbia.edu, 816 Mudd, 212-854-2869

Opportunities

- biology of the cell and applications: neurotransmission in the nervous system and release of neurotransmitters at neuronal synapses; fusion and crossing of cell membrane barriers; the mechanisms of infection by influenza, HIV, and Ebola viruses; force production and mechanosensing by cells; the mechanisms of cell division
- usage and development of image analysis software applied to complex cellular processes; analysis of cell-generated force maps on the cell environment
- computer projects: developing interactive web-based learning interfaces; JavaScript modules for dynamic graphic visualization; website development

Activities entail a weekly time commitment of 4 hours or more. Both academic credit and remunerative positions available. Term-time and summer positions available.

Contact: Professor Ben O'Shaughnessy, bo8@columbia.edu, 1006 Mudd, 212-854-3203

Opportunities

- carbon capture, utilization, and storage; sustainable energy conversion pathways
- investigation of coupled reaction kinetics and morphological structure changes for energy and environmental technologies
- development of novel nanoscale hybrid materials for energy and material conversion systems
- synthesis of liquid fuels and hydrogen from wastes and biomass
- synthesis of sustainable construction materials derived from industrial wastes
- extraction of unconventional energy sources (e.g., shale gas) with reduced environmental footprints (e.g., integrated CO_2 storage)
- development of urban mining technologies: extraction of elements from electronic wastes while internally recycling acids
- investigation of electrostatic charging phenomenon in multiphase flows

Research in this laboratory involves both experimental and modeling studies in catalytic and noncatalytic reactions related to energy and environmental systems. Undergraduate researchers are generally paired with graduate students on specific projects. However, independent research projects may be available for summer interns. The weekly time commitment is at least 10 hours. We only accept students who would commit to the project for more than a year since it takes about six months to train each student.

Contact: Professor A.-H. Alissa Park, ap2622@columbia.edu, 1038A Mudd, 212-854-8989

Opportunities

- electrochemistry, with applications in fuel cells, corrosion or metallization of electronic, magnetical, or mechanical devices

This opportunity involves primarily experimental work in support of doctoral research projects. The work provides exposure to basic electrochemical experiments and may involve some optical and electronic microscopy. Some opportunities may exist for enhancing the group's software infrastructure. Students should be prepared to commit approximately 6–8 hours per week in exchange for academic credit *(CHEN E3900: Undergraduate research project)*. Work-study opportunities may exist.

Contact: Professor Alan West, acw17@columbia.edu, 801 Mudd, 212-854-4453

Department of Civil Engineering and Engineering Mechanics

Chair: George Deodatis, 610 Mudd, 212-854-9728
civil.columbia.edu

Opportunities

- deterioration of cable-suspension bridge wires

This project has as its objective the understanding of the deterioration and fracture mechanism in high-strength, low-carbon steel wires that are used in cable suspension bridges. Laboratory tests on wires are conducted to determine the corrosion rate and the location of crack initiation. For academic credit, a minimum commitment of 5–10 hours per week is required.

- structural damage identification

This project focuses on the determination of computer algorithms for the automatic detection of damaged areas in structural systems. These algorithms use the structural response to some known excitations to provide mathematical and physical models that are capable of reproducing the dynamic behavior of the real structure. In this study, computer simulations on numerical and experimental tests are performed. For academic credit, a minimum commitment of 5–10 hours per week is required.

Contact: Professor Raimondo Betti, betti@civil.columbia.edu, 640 Mudd, 212-854-6388

Opportunities

- risk assessment and risk management of infrastructure

This project aims to assess the risk to the civil infrastructure (buildings, bridges, lifelines, etc.) arising from hazards in major metropolitan areas, both natural (earthquake, wind, landslides, etc.) and man-made (climate change, accidents, terrorism). Once the risk is assessed, the objective is to introduce innovative ways to mitigate the catastrophic consequences of the various hazards. The approach followed to address this problem is a multidisciplinary one, combining knowledge and techniques from the natural sciences, engineering, urban planning, economics, finance, and psychology.

- scientific and aesthetic analysis of large-scale structures

This project aims to analyze a series of large-scale structures (including bridges, buildings, and roof structures) from both a scientific and an aesthetic point of view. The social significance of the structures is also considered. The concept of structural art is studied, and emphasis is given to symbolic and historic structures.

- characterization of microstructure of heterogeneous materials

This project aims to develop methodologies to accurately quantify and describe the uncertain microstructure of two-phase materials. Applications in a wide range of materials, including concrete, cellular aluminum, graphite-epoxy fibrous composites, etc.

- reliability of fatigue-sensitive structures, including aircraft and ships

This project aims to develop techniques to assess the reliability of structures that are sensitive to fatigue. Methodologies are developed to estimate the deterioration of their reliability as a function of time and to introduce optimum nonperiodic inspection schedules. Emphasis is placed on aircraft and ships.

- simulation of stochastic processes and fields

This project aims to develop methodologies to digitally simulate stochastic processes and fields that can be used to model random actions on structures (e.g., earthquakes, wind, blast) or uncertain material and soil properties.

- stochastic finite element methods

This project aims at developing stochastic finite element methodologies for the analysis of structural systems with uncertainties in their system properties and external excitation. Emphasis is given in developing variability response functions for various quantities in linear and nonlinear problems.

Contact: Professor George Deodatis, deodatis@civil.columbia.edu, 630 Mudd, 212-854-9728

Opportunities

- natural ventilation

This project aims to develop and evaluate a box model for natural ventilation in a real building. The box model solves the equations describing the evolution of the building air and thermal mass temperatures, accounting for the different heat sources and sinks in the building. A comparison with measured data will be performed, and the influence of uncertain input parameters will be evaluated. Experience with MATLAB is desirable. For academic credit, a minimum commitment of 5–10 hours per week is required.

- RANS modeling of turbulent heat transfer

This project focuses on Reynolds-averaged Navier-Stokes modeling of turbulent heat transfer, considering test cases of academic and practical interest. The goal is to investigate the influence of the choice of the turbulence model and the wall function on the solution, in order to identify the model assumptions that introduce significant uncertainty in the solution. Experience with computational fluid dynamics is desirable. For academic credit, a minimum commitment of 5–10 hours per week is required.

- wind loading on a low-rise rectangular building

This project aims to investigate the accuracy of Reynolds-averaged Navier-Stokes models for predicting the mean and peak wind loading on a low-rise rectangular building. The results will be compared to available wind tunnel experiments and to data available from a previously performed large-eddy simulation to draw conclusions on the trade-off between computational cost and accuracy. Experience with computational fluid dynamics is desirable. For academic credit, a minimum commitment of 5-10 hours per week is required.

Contact: Professor Catherine Gorlé, catherine.gorle@columbia.edu, 630 Mudd, 212-853-0435

Opportunities

- microstructural characterization of cement-based materials
- rheological characterization of cement-based materials
- advanced cement composites
- sustainable infrastructural materials

Student participants are involved in the characterization, development, and performance evaluation of cement-based materials that incorporate advanced additives for enhanced performance and cement alternatives for increased sustainability. They will be exposed to various characterization techniques, including thermogravimetric analysis, isothermal calorimetry, x-ray diffraction, and rotational rheology, and mechanical testing at multiple scales.

Contact: Professor Shiho Kawashima, s-kawashima@columbia.edu, 616 Mudd, 212-854-2701

Opportunities

- stochastic structural dynamics
- nonlinear random vibration
- signal processing under limited data

The projects focus on the general area of mathematical modeling and dynamics of complex structural/mechanical systems with emphasis on uncertainty quantification aspects. The development of numerical and/or analytical techniques for nonlinear response determination and risk/reliability assessment of engineering systems/structures, as well as joint time-frequency analysis and spectral estimation under limited data, are of particular interest.

Students are requested to participate either for academic credit or on a volunteer basis. Activities include library research, mathematical/analytical derivations, and computer simulations (some experience in MATLAB is required). For academic credit, a minimum commitment of 10 hours per week is required. Prerequisites include *ENME E3106* and *CIEN E3111*.

Contact: Professor Ioannis Kougioumtzoglou, ikougiom@columbia.edu, 622 Mudd, 212-853-0462

Opportunities

- structural dynamics
- structural identification
- active control

Laboratory assistant positions, either for academic credit or on a volunteer basis, to participate in research projects involving dynamic testing using the medium-scale seismic shake table in the Carleton Laboratory. Research projects include structural system identification, damage detection, and adaptive control. Activities include test-model design and fabrication, dynamic response computer simulation, data acquisition, and library research. Some experience in MATLAB, dynamics/vibrations is desirable.

Contact: Professor Andrew Smyth, smyth@civil.columbia.edu, 636 Mudd, 212-854-3369

Opportunities

- simulating fracking

The objective of this project is to simulate hydraulic fracture in fluid-infiltrating shale and mudstone. Students must have solid background in finite element analysis and must be able to implement basic models in MATLAB. For academic credit, a minimum commitment of 10 hours per week is required. This undergraduate research might be funded depending on the outcome of a pending grant. Prerequisite: *ENME E3332* or by permission.

- analyzing porous media with hydrodynamics simulations and graph theory

This project aims to analyze changes of hydraulic properties of granular materials subjected to shear loading by simulating flow inside pores of microstructures of granular materials. Students are expected to have taken a fluid mechanics course and have basic understanding in C++ and MATLAB. For academic credit, a minimum commitment of 10 hours per week is required.

- analytical solution of leak-off in hydraulic fracture

This project is concerned with the near-tip region of a fluid-driven fracture propagating in a permeable rock. Basic understanding of asymptotic analysis is helpful but not required. For academic credit, a minimum commitment of 10 hours per week is required. Prerequisites: *ENME E3332* and *ENME E6320* or by permission.

- poroelastic structural element

This project aims to analyze buckling of poroelastic beam, plate, and shell elements. Basic understanding of elasticity is required. Ability to implement two-dimensional elasticity problem in MATLAB is required. For academic credit, a minimum commitment of 10 hours per week is required.

- dynamic wave propagation of saturated porous media

The objective of this research is to understand how compressive and shear waves propagate in porous media under isothermal and nonisothermal conditions. Basic understanding of Green's function and Laplace's transform is required. For academic credit, a minimum commitment of 10 hours per week is required.

Contact: Professor Steve WaiChing Sun, wsun@columbia.edu, 614 Mudd, 212-851-4371

Opportunities

- computational fracture mechanics

Students work on computer simulations and algorithm development involving advanced finite element techniques to model fracture and multiphase materials. This requires basic knowledge in finite element methods. For academic credit, a minimum commitment of 5–10 hours per week.

- intensive computations on parallel supercomputers

Students employ supercomputers at Columbia University to model very large problems in elasticity, e.g., models of an entire building with millions of unknowns, using finite element codes. For academic credit, a minimum commitment of 5–10 hours per week.

- damage-induced corrosion (in collaboration with Professor Betti)

Students study and develop corrosion models from experiments to characterize the rate and direction of the damage. Models are then implemented in computer simulations of damaged structures. Literature research is also expected. For academic credit, a minimum commitment of 5–10 hours per week.

- structural health monitoring (in collaboration with Professor Smyth)

The project involves experimental testing and calibration of numerical models to detect damage (cracks and holes) in structures. For academic credit, a minimum commitment of 5–10 hours per week.

- contact mechanics

This project involves mathematical formulation of simple contact problems in mechanics and their solution with various numerical techniques. For academic credit, a minimum commitment of 5–10 hours per week.

Contact: Professor Haim Waisman, hw2286@columbia.edu, 610 Mudd, 212-851-0408

Opportunities

- rheological tests of warm mix asphalt

This project tests the use of some additives to improve the flowability of asphalt materials so they can be produced at lower temperatures and thereby reduce energy consumption and gas emissions. This concept also explores other technologies such as fiber-reinforced asphalt, recycled asphalt, and rubberized asphalt. Laboratory assistant positions for academic credit are available for material testing and modeling. The weekly time commitment is 10 hours. Students should have basic training in laboratory testing and fundamental knowledge of solid mechanics.

- long-term performance of polymer materials

When polymer materials serve under certain aging or weathering conditions, the mechanical properties will significantly change. This project tests the long-term performance with some short-span tests in the Carleton Laboratory. Laboratory assistant positions for academic credit are available for material testing and modeling. The weekly time commitment is 8 hours. Students should have basic training in laboratory testing and fundamental knowledge of solid mechanics.

- fracture characterization of multilayered materials

Multilayered materials have been used in engineering practice for structure and material reinforcement, protective coating, thermal insulation, and infrastructure maintenance and rehabilitation. However, fractures are often found in the weak layers. This project studies the fracture pattern and predicts the fracture behavior of multilayered materials. Laboratory assistant positions for academic credit are available for material testing and fracture modeling. The weekly time commitment is 8 hours. Students should have basic training in laboratory testing and fundamental knowledge of solid mechanics.

Contact: Professor Huiming Yin, yin@civil.columbia.edu, 634 Mudd, 212-851-1648

Department of Computer Science

Chair: Professor Julia Hirschberg, 450 CSB, 212-939-7005
www.cs.columbia.edu

Opportunities

- mobile robotics
- computer vision
- tactile sensing
- 3D modeling

Activities include working on software and hardware projects in the Columbia Robotics Lab. Some current projects include automated 3D site modeling of outdoor structures, graphical simulation of multifingered grasping, 3D reconstruction of objects, and medical robotics. Research positions carry academic credit and may extend into summer and/or have remuneration. Weekly commitment is about 10 hours. Students should be able to work independently; have completed *COMS W3137: Data structures and algorithms;* and have had some experience with either computer vision, robotics, or graphics. Details on research in the Columbia Robotics Lab can be found at www.cs.columbia.edu/robotics.

Contact: Professor Peter Allen, allen@cs.columbia.edu, 619 CEPSR, 212-939-7093

Opportunities

- computer architecture
- design and programming of system-on-chip platforms
- wireless sensor networks
- combinatorial optimization algorithms
- computer-aided design for embedded systems and integrated circuits

Opportunity to work on graduate-level research projects. These include hardware-software co-design of energy-efficient accelerators for critical algorithms and their integration into a system-on-chip, design of networks-on-chip, embedded software programming of wireless sensor networks, and software development of prototype computer-aided design (CAD) tools for integrated circuits and embedded systems. Projects can be done for academic credit, and continuation over the summer is possible. Projects may be done independently or as part of a larger team. Based on the particular type of project, one or more of the following prerequisites are necessary: proficiency in data structures and at least one high-level programming language (C, C++, Java), Linux programming, knowledge of digital hardware design and computer organization, fundamentals of digital integrated circuits design, and knowledge of a hardware description language (VHDL, Verilog).

Contact: Professor Luca Carloni, luca@cs.columbia.edu, 466 CSB, 212-939-7043

Opportunities

- algorithms running on social networks
- models, analysis, and optimization of dynamic graphs
- measurement of the social web and mobile apps
- game theory and computational economics
- issues when dealing with massive amounts of private information

How do the web and our smartphones handle and mine our personal information? How

can we reconcile the progress they promise with our privacy? Research projects involve real hands-on monitoring and crawl of current popular apps, the economics of the data these algorithms produce, and more efficient alternative design.

Requirements: good knowledge of discrete maths and probability; proficiency with data structure and a programming language (Python, C, Java). For academic credit: commitment of 9–12 hours of work per week. Could be more for summer support. Participation in our reading group and regional research events encouraged. Nonmajors are also welcome, especially when relevant domain expertise is appropriate.

Contact: Professor A. Chaintreau, augustin@cs.columbia.edu, CEPSR 610, 212-939-7082

Opportunities

- algorithmic game theory and economics
- computational complexity and theory

Activities include paper study and research-oriented projects of topics in algorithmic game theory and complexity theory, possibly for academic credit and/or remuneration. Projects include the study of applications, both theoretical and practical, of game theory and mathematical economics in computer science. Solid math background is required.

Contact: Professor Xi Chen, xichen@cs.columbia.edu, 503 CSB, 212-939-7136

Opportunities

- embedded system development
- device driver development
- domain-specific languages
- compilers
- computer-aided design tools

Projects include embedded system design and development, device driver development, design and implementation of domain-specific languages and their compilers, and development and implementation of algorithms for synthesizing hardware and software from the real-time language Esterel. Projects are ongoing and can be done for academic credit either during the term or over the summer. Knowledge of C/C++, operating systems, digital hardware design, optimization algorithms, and compilers is desirable. Projects may be done independently or as part of a larger team.

Contact: Professor Stephen Edwards, sedwards@cs.columbia.edu, 462 CSB, 212-939-7019

Opportunities

- augmented reality and virtual reality
- collaborative, mobile, and wearable computing
- tracked, see-through/hear-through head-worn displays
- knowledge-based generation of multimedia presentations
- personal health management user interfaces
- multimodal user interfaces
- information visualization
- computer games
- 3D GUI design

These opportunities involve the design and implementation of 3D and 2D computer graphics and user interface software for indoor and outdoor users, using a range

of displays and interaction devices: head-worn, hand-held (from smartphones to tablets), wrist-worn, tabletop, and wall-sized. Multidisciplinary projects potentially involve interaction with faculty in other departments, schools, and institutions, including Anesthesiology, Architecture, Biomedical Informatics, Electrical Engineering, Journalism, Mechanical Engineering, Music, Nursing, Teachers College (Cognitive Science), and NewYork-Presbyterian Hospital. Research positions provide academic credit or remuneration and are offered during fall, spring, and summer. Weekly commitment is about 10 hours, and the prerequisites are completion of: *COMS W4160: Computer graphics, COMS W4170: User interface design, COMS W4172: 3D user interfaces and augmented reality,* or equivalent experience/courses; and software design and development expertise.

Contact: Professor Steven Feiner, feiner@cs.columbia.edu, 609 CEPSR, 212-939-7083

Opportunities

- database systems
- web search
- social media analysis

Programming and research-oriented projects to develop search and analysis tools for the Internet. Academic credit and continuation over the summer possible. Weekly commitment is 10 hours. Prerequisites: *COMS W3137: Data structures and algorithms; COMS W4111: Introduction to database systems;* and programming experience in Java, C, C++, or Python.

Contact: Professor Luis Gravano, gravano@cs.columbia.edu

Opportunities

- deceptive speech across cultures
- tools for endangered languages (some linguisitics background is necessary)
- code-switching identification: mixing multiple languages in conversation (text and speech)
- text-to-speech synthesis for low resource languages
- emotional text and speech
- extracting information about entertainers from IMDB

Data analysis and computational modeling, human subjects design and execution, machine learning experiments, providing academic credit during fall, spring, and summer. Commitment of 9–12 hours per week is expected. *COMS W3137: Data structures and algorithms* is required. Courses in speech or language processing as well as machine learning are useful. See project descriptions at www.cs.columbia.edu/speech/projects.cgi.

Contact: Professor Julia Hirschberg, julia@cs.columbia.edu, 705 CEPSR, 212-939-7114

Opportunities

- algorithmic statistics and machine learning
- large-scale machine learning
- applications of machine learning to astronomy, information retrieval, natural language processing

Activities include paper study, implementation and empirical study of machine learning algorithms, and theoretical analysis of machine learning algorithms. Strong programming and machine learning background required for empirical work; strong math and theory background required for theoretical work. Academic credit and/or remuneration is possible.

Contact: Professor Daniel Hsu, djhsu@cs.columbia.edu, 702 CEPSR, (212) 939-7046

Opportunities

- postdeployment checking for bugs, security vulnerabilities, and privacy breaches
- finding bugs in machine learning, data mining, and big data applications
- graphical analysis of program behaviors to discover opportunities for new APIs
- reducing testing overhead during continuous integration/deployment processes
- exploring applications of symbolic execution to testing, debugging, and patch validation

The Programming Systems Lab (PSL) conducts research at the boundary of software engineering and software systems, focusing on software reliability, privacy and security, and social software engineering. We are always seeking new project students to join us.

At present, we are seeking students for individual and team research and development projects, possibly some user studies. Preference is for students interested in participating for multiple consecutive semesters, potentially including summer(s). Prerequisites (except as otherwise specified for particular projects): *COMS W3157* or equivalent programming experience in Java or C/C++. Recommended corequisites: any one or more of *COMS W4111: Introduction to databases, COMS W4115: Programming languages and translators, COMS W4118: Operating systems, COMS W4156: Advanced software engineering, COMS W4444: Programming & problem solving* are desirable, but not necessary. Nonmajors are very welcome, particularly students with background in applied math or statistics. Time commitment approximately 12 hours per week for a 3-point project. However, projects are graded based on results rather than effort, so prospective project students must have strong time management and organizational skills. Unless specified otherwise for the particular project, most work will be conducted in the Programming Systems Lab, located in 6LE1 CEPSR; some work can be conducted remotely. Projects are only available for academic credit.

Contact: Professor Gail Kaiser, kaiser@cs.columbia.edu; or
Jonathan Bell, jbell@cs.columbia.edu

Opportunities

- video understanding: segmentation, indexing, and cross-referencing of movies, sitcoms, newscasts, documentaries, YouTube videos, etc.
- video virality and video evolution in large depositories
- synthesis of video summaries, in both video and natural language form
- derivation and improvement of video tags, and their semantics and ontologies
- analysis of human gestures and their relationship to video semantics
- design and improvement of semantic-based video browsers
- performance evaluation of algorithms for all of the above

Activities include paper study, library research, systems design, computer analysis, and mathematical modeling. Research positions carry academic credit; some limited work study for pay is also available. Both are available year-round. Weekly commitment is about 10 hours. Students must be able to work independently, must have completed *COMS W3137: Data structures and algorithms,* and must be proficient in C, C++, Java, or Python. Completion of *COMS W4701: Artificial intelligence* and/or *COMS W4731: Computer vision* and/or *COMS W4735: Visual interfaces to computers* is desirable but not necessary.

Contact: Professor John Kender, jrk@cs.columbia.edu, 622 CEPSR, 212-939-7115

Opportunities

- computer and network security
- denial of service
- worms and viruses
- access control
- cryptographic protocol design and evaluation
- wireless security
- systems aspects of security

Software design and implementation, paper study, application projects, and/or library research providing academic credit during fall, spring, and summer. Commitment of 9–12 hours per week is expected. *COMS W3137: Data structures and algorithms* is required; *COMS W4180: Network security, COMS W4118: Operating systems,* and *COMS W4119: Computer networks* are desirable. One or more of the following languages are required: C, C++, Java.

Contact: Professor Angelos D. Keromytis, angelos@cs.columbia.edu, 515 CSB, 212-939-7095

Opportunities

- computer architecture
- hardware/software interaction
- parallel hardware and software systems
- on-chip communication networks

Research projects involve measurement, design, simulation, and analysis of computer architectures. We have specific studies under way in the areas of reconfigurable hardware design and programming of heterogeneous, asymmetric multicores. Software-oriented projects are available. Ideally, students would have taken (or be taking) a hardware-oriented course (*COMS W4824* or *EECS W4340*) or an advanced programming class (*COMS W3157*). Strong programming skills (either hardware or software) are required.

Contact: Professor Martha Kim, martha@cs.columbia.edu, 469 CSB, 212-939-7094

Opportunities

- cryptography

Activities include paper study, theoretical research, or cryptographic implementation. Research positions carry academic credit. Some limited paid positions may also be available. Weekly commitment of 6–12 hours is required. Students must be able to work independently, must have completed *COMS W4261: Introduction to cryptography*, and must be able to understand and write formal definitions and proofs. Theoretical projects additionally require completion of *COMS W3261: CS theory*, and preferably also *COMS W4236: Introduction to computational complexity*. Implementation projects additionally require proficiency in at least one of C, C++, Java.

Contact: Professor Tal Malkin, tal@cs.columbia.edu, 514 CSB, 212-939-7097

Opportunities

- natural language generation
- machine translation
- question answering on the web
- statistical processing for natural language
- text summarization

Programming projects involving development of tools for natural language generation and statistical analysis. Academic credit and continuation over the summer possible. Weekly commitment is 10 hours. Prerequisites: *COMS W4701: Artificial intelligence;* LISP and C. Preferred: *COMS W4705: Natural language processing*.

Contact: Professor Kathleen McKeown, kathy@cs.columbia.edu, 722 CEPSR, 212-939-7118

Opportunities

- operating systems
- mobile computing
- network, Internet, and thin-client computing
- virtualization
- iPhone and Android applications

Software design and implementation, paper study, application projects, and/or library research providing academic credit during fall, spring, and summer. Commitment of 9–12 hours per week is required. *COMS W3137: Data structures and algorithms* is required; *COMS W4118: Operating systems* and/or *CSEE W4119: Computer networks* is desirable. One or more of the following languages are required: C, C++, Java.

Contact: Professor Jason Nieh, nieh@cs.columbia.edu, 518 CSB, 212-939-7160

Opportunities

- computer-aided design tools for digital systems
- asynchronous digital circuits: design and simulation
- fault-tolerance/error-correction
- optimization algorithms

Research possibilities include (1) software CAD (computer-aided design) tools for digital systems and (2) digital circuit design and simulation. The focus of this research is on clockless or asynchronous digital circuits, which support scalable system design, low-power, and tolerance of variability. Opportunity to work on graduate-level research projects. Commitment of 10–12 hours per week is required. Continuation over the summer is possible, with 20–40 hours per week. Prerequisites: (1) basic digital logic and computer organization (*CSEE W3827: Fundamentals of computer systems,* or equivalent), and (2) advanced digital logic (*CSEE W4823: Advanced logic design,* or equivalent background). Additional background is desirable, but is not required, in either VLSI or hardware design (*ELEN E4321: Digital VLSI circuits, EECS W4340: Computer hardware design,* or equivalent) or in computer-aided design (*CSEE E6861: CAD of digital systems*).

Contact: Professor Steven Nowick, nowick@cs.columbia.edu, 508 CSB, 212-939-7056

Opportunities

- computational genetics
- systems biology
- comparative genomics
- bioinformatics

Computational biology is a young field aimed at understanding life sciences by computerized analysis of high throughput experimental data. Opportunities are available for talented students with strong interests in this interdisciplinary field. Quantitative thinking is required, and for different projects either programming skills or background biomedical sciences are required. Depending on the project and candidate, academic credit or pay is possible. Specific projects are focused on personalized medicine, inference of genetics of ancestral human populations, reverse engineering of cellular information processing, and cancer genomics.

Contact: Professor Itsik Pe'er, itsik@cs.columbia.edu, 505 CSB, 212-939-7135

Opportunities

- Internet multimedia protocols and applications
- Internet measurements and infrastructure
- Internet applications, economics, and policy

Design, simulation, and implementation providing academic credit (also summer) in exchange for a 5-hour weekly commitment. Satisfactory completion of *COMS W3157: Advanced programming* or equivalent is required. *CSEE W4119: Computer networks* is desirable. Excellent background is required in one or more of the following languages: C, C++, Java, Python, PHP.

Contact: Professor Henning Schulzrinne, hgs@cs.columbia.edu, 723 CEPSR, 212-939-7042

Opportunities

- computational complexity theory
- computational learning theory

Activities include paper study and computer experiments with learning algorithms and simulations, possibly for academic credit and/or remuneration. Strong math and theoretical computer science background (including 4000-level course work), good programming skills, and/or strong familiarity with mathematical software packages such as Maple, Mathematica, etc., are required.

Contact: Professor Rocco Servedio, rocco@cs.columbia.edu, 517 CSB, 212-939-7065

Opportunities

- computer hardware design and validation
- computer architecture
- clean slate design of secure computer systems

A unique opportunity to work in a fun and challenging environment in the Computer Architecture and Security Technologies Lab. Research activities include paper study, understanding hardware, software design and development, and application analysis for academic credit. Projects may be individual or pair projects. Some of these projects are multidisciplinary and potentially may involve interaction with other faculty and labs in CS. Roughly 10-hour weekly commitment. Prerequisites: strong problem-solving skills, good GPA, eagerness to learn, and good programming skills.

Contact: Professor Simha Sethumadhavan, simha@cs.columbia.edu, 465 CSB, 212-939-7062

Opportunities

- computer and network security
- intrusion detection
- insider and masquerade attack detection
- Android mobile security
- embedded system security

Software design and implementation, paper study, application projects, and/or library research providing academic credit during fall, spring, and summer. Commitment of 9–12 hours per week is expected. *COMS W3137: Data structures and algorithms* is required; *COMS W4180: Network security, COMS W4771: Machine learning,* and *CSEE W4119: Computer networks* are desirable. One or more of the following languages are required: C, C++, Java.

Contact: Professor Salvatore J. Stolfo, sal@cs.columbia.edu, 606 CEPSR, 212-939-7080

Opportunities

- iPhone/Android/Facebook app programming
- web applications
- software development tools
- study of open-source software
- study of mobile or web applications
- operating systems

Research activities include software design and implementation, paper study, and data analytics. Research positions provide academic credit or remuneration and are offered year-round. Research outcome may include open-source software release, iPhone/Android/Facebook apps, and research publications at top conferences. Commitment of 9–12 hours per week is required. Solid programming skills in any programming language are a big plus. One or more of the following languages/frameworks are required: C, C++, Java, Javascript, PHP, CakePHP, Python, Django, Ruby, Ruby on Rails. Top students will receive funding for the project.

Contact: Professor Junfeng Yang, junfeng@cs.columbia.edu, 460 CSB, 212-939-7012

Earth and Environmental Engineering
Henry Krumb School of Mines

Chair: Professor Peter Schlosser, 918 Mudd, 212-854-2905
eee.columbia.edu

Opportunities

- enhanced global sanitation and resource recovery from wastewater
- design and application of bioprocess technologies for addressing global water, sanitation, and hygiene (WASH)
- wastewater treatment and climate change
- water and big data
- impact of microbial interactions on environmental and public health

The environmental genomics and biotechnology labs offer excellent opportunities to work on independent as well as graduate student projects. Activities include development of water, sanitation, and hygiene (WASH) approaches to serve the communities worldwide that are in most need of these services but do not have adequate resources to do so. Our group adopts a fundamental approach using environmental engineering and microbiological techniques to address this issue. Activities of students involved include designing and operating lab-scale and pilot-scale reactors systems to solve pressing WASH needs, cultivation and maintenance of mixed and pure bacterial cultures and communities, characterizing the identity, abundance, and activity of these communities by using state-of-the-art molecular techniques, modeling the interactions within the communities using mathematical models, and examining the environmental and public health impacts of select microbial activities. Students working on these positions can receive either academic credit or work-study remuneration. Research activities may extend into summer. Minimum weekly commitment to earn academic credit is 10 hours.

Contact: Professor Kartik Chandran, kc2288@columbia.edu, 212-854-9027

Opportunities

- morphogenesis: why fruits/vegetables have distinct appearances; how to explain the patterns found in various animals, cells, tissues; how to create bioinspired components in engineering
- energy: how to harvest electricity from ambient and otherwise-wasted thermal and mechanical sources for enhanced energy efficiency and sustainability; how to protect systems from hazards and attacks by absorbing harmful energy; how to create a nanoscale thermal machine and electric machine
- environment: how to overcome the bottleneck of carbon sequestration; how to selectively capture carbon dioxide from air
- proteins/cells: how do the proteins interact with each other and respond to external stimuli? how to simulate whole cell behavior in a multiscale approach
- nanoindentation: how to measure the mechanical properties of small material structures in quick and efficient ways; what are the properties of advanced materials and biosystems?

The micro/nano/biomechanics group offers excellent opportunities to work on independent as well as graduate student projects. The opportunities may provide academic credit or be work-study eligible. Details on research can be found at www.columbia.edu/~xc2107

Contact: Professor Xi Chen, xichen@columbia.edu, 212-854-3787

Opportunities

- removal of heavy metals and organic contaminants from sediments
- lowering energy use and carbon dioxide emissions by fuel-assisted electrolytic metal extraction
- recovery of heavy metals by recycling of industrial wastes

Paper study, mathematical projects, library research, computer analysis, and electrochemical research activities for academic credit or remuneration, either term-time or summer for junior and senior students. The weekly time commitment is 10 hours during the semester and 30 hours during the summer.

Contact: Professor Paul Duby, pfd1@columbia.edu, 905 Mudd, 212-854-2928

Opportunities

Our research is focused on solving real world issues using catalytic materials. Our programs reflect my 40+ years of research in the catalyst industry developing materials for air pollution reduction (i.e., the catalytic converter in automobiles) and alternative energy, with special emphasis on the hydrogen economy and upgrading carbon dioxide to useful products. Our research is mostly funded by industry and offers both graduate and undergraduate students the opportunity to work in concert with scientists and engineers in leading industrial companies addressing future energy and environmental issues.

Contact: Robert J. Farrauto, rf2182@columbia.edu, 926C Mudd, 212-854-6390, columbia.edu/cu/catalysis-environment

Opportunities

- prediction of flood, hurricane, and drought risk using climate forecasts
  a. U.S. (Sacramento, Colorado, East Coast) and international (Brazil, Africa, Central Asia) applications
  b. water hazards, impacts, and response
- energy and water demand forecasting, systems operation, and risk management
  a. America's water: how to estimate and meet future needs in rural and urban settings, in a changing environment
  b. environmental regulation, ecological objectives, and the systems approach to option evaluation
  c. water-related financial risks in the mining industry
- nonlinear dynamics and chaos
  a. data-based prediction and system identification
  b. numerical models of interacting nonlinear oscillators with examples from climate and water systems
  c. statistical identification of predictability from time series
  d. experiments for complex planetary systems to explore the occurrence, sustenance, and self-regulation of life and climate on Earth
- sustainable management of the environment
  a. solutions for regional planning and development
  b. competition, stakeholder perspectives, and the role of science in informed public and private sector decisions

A number of interrelated projects focus on exploring the function of water-dependent

natural systems at scales ranging from river basins to hemispheres, and hours to millennia. The goal is to develop an empirical understanding of how this apparently fragile system works, how patterns emerge and lead to catastrophe (hazard or life), and how we can use this knowledge to better manage resource use and the environment by introducing this information to appropriate social institutions. The student is exposed to numerical and statistical modeling; integration of economics, environmental analysis, and mechanistic modeling; and elicitation of social factors as design objectives; and develops computer skills (GIS, high- and low-level languages). The opportunities provide academic credit and work-study wages, and require up to 12 hours weekly.

Contact: Professor Upmanu Lall, ula2@columbia.edu, 840 Mudd, 212-854-8905

Opportunities

- carbon capture, utilization, and storage; sustainable energy conversion pathways
- investigation of coupled reaction kinetics and morphological structure changes for energy and environmental technologies
- development of novel nanoscale hybrid materials for energy and material conversion systems
- synthesis of liquid fuels and hydrogen from wastes and biomass
- synthesis of sustainable construction materials derived from industrial wastes
- extraction of unconventional energy sources (e.g., shale gas) with reduced environmental footprints (e.g., integrated CO_2 storage)
- development of urban mining technologies: extraction of elements from electronic wastes while internally recycling acids
- investigation of electrostatic charging phenomenon in multiphase flows

Research in this laboratory involves both experimental and modeling studies in catalytic and noncatalytic reactions related to energy and environmental systems. Undergraduate researchers are generally paired with graduate students on specific projects. However, independent research projects may be available for summer interns. The weekly time commitment is at least 10 hours. We only accept students who would commit to the project for more than a year since it takes about six months to train each student.

Contact: Professor A.-H. Alissa Park, ap2622@columbia.edu, 1038A Mudd, 212-854-8989

Opportunities

- interactions of green surfactants/polymers/proteins in solution and at interfaces
- sustainable mineral resource recovery: fundamental and applied research, new reagents, and new technology
- nanotoxicity: effect of morphology and coatings of nanoparticles on their (bio) chemical activity
- environmental engineering (effluent recycling and soil remediation, fate and role of nanoparticles in the environment)
- interfacial phenomena applied to mineral surfaces, nanomaterials, bioimplants
- nanogels as new smart materials for tissue engineering: design of nanogel-cell interactions to control cytotoxicity and cell growth
- improved performance of surfactants and polymers in cosmetics and health care products

Activities include mechanical assembly, measurements of materials properties, spectral measurements, computational analysis, and minor experiments. The opportunities may provide academic credit or be work-study eligible. The weekly commitment is 10 hours.

Contact: Professor Ponisseril Somasundaran, ps24@columbia.edu, 905 Mudd, 212-854-2926

Opportunities

- advance innovative membrane-based technologies for water and energy production
- fabrication of novel membranes for greater sustainability performance
- mechanistic, thermodynamic, and kinetic studies of membrane processes
- development of resource "mining" strategies for wastewater

The water-energy-environment group offers opportunities for extensive research experience. Undergraduates will be involved in all aspects of research: from literature review to hands-on in the lab to data analysis to research communication. Students will initially work with senior researchers but progressively gain ownership of their own projects. Undergrads can receive either academic credit or work-study remuneration, and research activities may extend into the summer. Minimum weekly commitment to earn academic credit is 10 hours. Students committed to research are encouraged to apply.

Contact: Professor N.Y. Yip, nyy2002@columbia.edu

Department of Electrical Engineering

Chair: Professor Keren Bergman, 1305 Mudd, 212-854-3105
ee.columbia.edu

Opportunities

- biological sequence analysis
- mining of publicly available biomolecular data
- biomolecular interaction inference
- development of diagnostic biomarkers for cancer

Opportunities for senior students who are willing to commit at least 10 hours per week for academic credit. Qualifications include a minimum GPA of 3.5, programming expertise, and some formal course work in molecular biology.

Contact: Professor Dimitris Anastassiou, anastas@ee.columbia.edu, 719 CEPSR, 212-854-3113

Opportunities

- optical interconnection networks for performance computing systems
- silicon photonic on-chip networks
- FPGA programming and control of optical systems

Research projects in the Lightwave Systems and Networks Laboratory involve the design and construction of fiber-optic modules, high-speed optical data testing, and application-specific electronic circuitry packaged to interface with the photonic devices. Participating students learn all aspects of experimental work in fiber optics as well as system-level design aimed toward the application of photonic packet switching to high-performance computing. Participating students are normally in their junior or senior year. For a minimum commitment of 10 hours per week, students can receive academic credit.

Contact: Professor Keren Bergman, bergman@ee.columbia.edu, 1305 Mudd, 212-854-1744

Opportunities

- multimedia information retrieval
- video analysis and object detection
- machine learning, social multimedia

Research and application development projects are available in the Digital Video and Multimedia Laboratory (www.ee.columbia.edu/dvmm). There are opportunities for individual studies as well as participation in ongoing research projects. Research assistants with stipends or research course credit. Background in computer vision or machine learning is useful. Basic programming skills (e.g., MATLAB, Python, Java, or C++) are required.

Contact: Professor Shih-Fu Chang, sfchang@ee.columbia.edu, 212-854-6894

Opportunities

Our research focuses on the design, simulation, and measurement of analog, radio-frequency, and power-integrated circuits in advanced IC technologies and on the novel systems or applications they enable in communications, sensing, and power management.

- design and implementation of autonomous sensor nodes for the Internet of Things
- design of analog or RF integrated circuits in nanoscale CMOS technologies
- experimental characterization of devices or custom integrated circuits or systems
- development of design and simulation software (CAD) for design productivity improvement

There are several opportunities to set up projects that involve the design and implementation of novel hardware ideas. Students can also participate in ongoing research, including integrated circuit design, circuit simulation, construction of breadboard models of novel circuit or system concepts, and/or experimental verification of fabricated circuits. Qualifications include a strong GPA and course work in electronics and circuits; familiarity with CAD tools is a requirement for some projects. For a commitment of 10 hours per week, students can receive academic credit. Paid summer projects are available.

Contact: Professor Peter Kinget, kinget@ee.columbia.edu, 818 CEPSR, 212-854-0309; www.cisl.columbia.edu/kinget_group/involvement.html

Opportunities

- GPU and parallel computation for mobile heterogeneous system architectures; applications in data and signal processing and communications
- programming projects using Open CL or CUDA on parallel machines; requires good knowledge of C language and background in data and signal processing
- Internet of Things—varied projects spanning aspects from communications to data analytics
- wireless communications: 5G wireless, latency, integration with Internet of Things

Contact: Zoran Kostic, zk2172@columbia.edu, CEPSR 813, 212-851-0269

Opportunities

The Columbia high-Speed and Millimeter-wave IC (CoSMIC) lab conducts research on novel devices, circuits, and systems for a variety of radio-frequency (RF), millimeter-wave, and terahertz applications, including novel communication systems, radar, imaging, and sensing. Currently, we have openings in the following projects:

- full-duplex radios (radios that transmit and receive at the same time and at the same frequency)
- millimeter-wave arrays for mobile communications
- massive MIMO communications systems

Typical projects involve one or more of the following activities: analog, RF, or millimeter-wave circuit design; electromagnetic simulations and modeling; construction of wireless system demonstrators; design of high-frequency PC boards and test fixtures; digital signal processing for communication systems and its implementation on FPGAs, etc. Successful candidates must have a strong GPA, course work related to circuits and/or electromagnetism, and, most importantly, initiative and work ethic.

Contact: Professor Harish Krishnaswamy, harish@ee.columbia.edu, 1025 CEPSR, 212-854-8196, www.ee.columbia.edu/~harish/index.html

Opportunities

- organic thin film optoelectronic device fabrication and characterization
- analog/digital system interface design, construction, and testing
- laboratory course project development

Research generally involves design, fabrication, packaging, or characterization projects using organic thin film optoelectronic devices. Fabrication is typically performed in the clean room and the group's facilities under the supervision of a graduate student mentor. Opportunities include projects for credit during the school year, work-study, and paid summer positions.

Contact: Professor Ioannis (John) Kymissis, johnkym@ee.columbia.edu, 1013 CEPSR, 212-854-4023

Opportunities

- reverse engineering the fruit fly brain
- neural coding and spike processing in sensory systems
- modeling the olfactory system and the visual system of the fruit fly
- massively parallel neural computation

Programming projects involving the development of models of brain circuits and architectures. Academic credit and continuation over the summer possible. Weekly commitment is 10 hours. Prerequisites: *BMEB E4020* and excellent knowledge of MATLAB.

Contact: Professor Aurel A. Lazar, aurel@ee.columbia.edu, 819 CEPSR, 212-854-1747

Opportunities

- variation-adaptive VLSI circuits and system design
- IC design for signal processing and machine learning workload
- hardware design for security function
- hardware design for fully-implantable brain computer interface (BCI) devices

We can offer several research opportunities based on the skill set of the applicants, including MATLAB-level simulations, FPGA prototyping, computer architecture exploration, integrated circuit design, and programming for CAD-tool development. Qualifications include a strong GPA and course work in electronics and circuits.

Contact: Professor Mingoo Seok, mgseok@ee.columbia.edu, 1012 CEPSR, 212-854-1701, www.ee.columbia.edu/~mgseok

Opportunities

Our laboratory in Columbia's Northwest Corner Building is exploring nanoscale CMOS integrated circuits for new applications in the life sciences as well as exploring novel devices based on biological materials and new solid-state materials.

- graphene-based devices and circuits
- membrane-based biological devices
- magnetic materials for power converters
- single-molecule sensors and systems
- neural interfaces

Research projects could include circuit and layout design of integrated circuits, protein purification, cell cultures, nucleic acid diagnostics, solid-state device fabrication. Opportunities include projects for credit during the school year and paid summer positions. Given the broad and multidisciplinary nature of the work in my group,

we would entertain students from most Engineering departments, in particular Electrical Engineering, Biomedical Engineering, Chemical Engineering, or Mechanical Engineering, as well as students in the College, Biological Sciences, Chemistry, or Physics.

Contact: Professor Ken Shepard, shepard@ee.columbia.edu, 1019 CEPSR, 212-854-2529

Opportunities

- develop and test algorithms for image and video analysis tasks, including recognition, image enhancement, detection, and tracking.
- compressed sensing and signal acquisition
- sparse representations of data
- robust machine learning with corrupted features
- matrix and tensor data analysis

We have programming projects, experimental/exploratory projects, and more theoretical work available for interested and qualified students. Course credit is available, as well as summer paid positions. Students should be comfortable with linear algebra and probability. Additional coursework in signal processing/learning/vision is a plus but not strictly necessary. Students should enjoy mathematics and making things, and be eager to explore new areas.

Contact: John Wright, johnwright@ee.columbia.edu

Opportunities

- wireless networking
- mobile and vehicular networking
- design, implementation, and evaluation of networking algorithms

Research projects involve design, analysis, and implementation of protocols for wireless and mobile networks. The protocols support efficient distributed operation in a mobile environment over an unreliable wireless channel. For examples of past projects, see enhants.ee.columbia.edu. Requirements: course work in algorithms, good programming skills, and preferably a networking-oriented course (e.g., *CSEE W4119* or *ELEN E4720*). For a commitment of 10 hours per week, students can receive academic credit. Summer projects are also available.

Contact: Professor Gil Zussman, gil@ee.columbia.edu, 811 CEPSR, 212-854-8670

Department of Industrial Engineering and Operations Research

Chair: Garud Iyengar, 313 Mudd, 212-854-2492
ieor.columbia.edu

Opportunities

- pricing of derivatives: develop and evaluate computational methods for pricing various financial contracts
- exchange-traded funds (ETFs) and related products: identify, quantify, and explain tracking performance of various ETFs; consistent pricing of options on leveraged ETFs with the same reference
- optimal trading algorithms: devise intraday static/dynamic trading strategies and backtest with high-frequency data. Additional related projects include long-term portfolios and options/futures trading problems.

Recent papers with a former M.S. and undergrad students: (For more papers, see https://sites.google.com/site/timleungresearch):

- ESO Valuation with Job Termination Risk and Jumps in Stock Price

SIAM Journal on Financial Mathematics, forthcoming, 2015 (with H.Wan, MSOR)

- Understanding the Tracking Errors of Commodity Leveraged ETFs

Commodities, Energy and Environmental Finance, M. Ludkovski et al. Editors, Springer. To appear, 2015 (with K. Guo, Class of 2014)

- Optimal Derivative Liquidation Timing Under Path-Dependent Risk Penalties

Journal of Financial Engineering, vol 2, issue 1, 2015 (with Y. Shirai, MS Program in FE)

Necessary background: Some programming (e.g., MATLAB, C/C++, R, or Python). Course work on statistics (e.g., regression) and stochastic processes (e.g., Markov chains, Brownian motion). Funding has been and will be available for outstanding committed students. Undergraduate/graduate students majoring in mathematics, applied math, statistics, and engineering are encouraged to inquire, attaching resume and transcript to e-mail.

Contact: Professor Tim Leung, tl2497@columbia.edu, 312 Mudd, 212-854-2942

Opportunities

- stochastic models in operations research
  a. stochastic simulation models of stochastic systems
  b. evaluate analytical approximations
  c. numerical algorithms for solving stochastic models

Recent projects have included: (1) studying congestion associated with inspecting shipping containers; (2) studying approximations for performance measures of queueing models of telephone call centers, including customer abandonment; (3) studying methods for determining staffing requirements in service systems with time-varying demand; and (4) studying new methods for numerically inverting transforms, with application to calculating system performance characteristics. Appropriate background: programming (e.g., C, C++, MATLAB), probability and statistics (*IEOR E3600* or equivalent), stochastic models (*IEOR E3106* or *E4106*), and simulation (*IEOR E4404*).

Contact: Professor Ward Whitt, ww2040@columbia.edu, 304 Mudd, 212-854-7255

For more opportunities, please visit the IEOR faculty bios at ieor.columbia.edu/directory/faculty.html.

Department of Mechanical Engineering

Chair: Professor Jeffrey Kysar, 220 Mudd, 212-854-7432
me.columbia.edu

Opportunities

- novel rehabilitation robot systems designs
- design of wearable sensors and electronics
- human evaluation and testing
- dynamic modeling, simulations, and control

Student participants are involved in the design of novel robotic systems for different human and industrial applications. Students will work in multidisciplinary teams of engineers, clinicians, and medical health care providers for design and evaluation of these systems.

Contact: Professor Sunil K. Agrawal, sunil.agrawal@columbia.edu, 230 Mudd, 212-854-2841

Opportunities

- cell mechanics
- tissue mechanics
- tissue engineering
- design of instrumentation for testing soft tissues
- software development for cell, tissue, and joint modeling
- modeling of growth

Student participants are involved in the testing of biological soft tissues for the determination of material and tribological properties, testing of cells for the assessment of their biophysical properties, design of instrumentation for performing such measurements, tissue engineering of cartilage, software development for modeling cells, tissues and joints, and modeling studies of tissue growth.

Contact: Professor Gerard A. Ateshian, ateshian@columbia.edu, 248 Mudd, 212-854-8602

Opportunities

- robotics
- robot hands, grasping and dexterous manipulation
- design and construction of tendon-driven mechanisms
- physics-based simulation and virtual environments

Want to design, build, control, simulate, or program intelligent mechanisms that can hold their own in the real world? The Mobile Manipulation Lab is starting a number of projects in the field of robotics-the science of interacting with the environment. Students can get involved in any/all of the mentioned topics and learn how they interact and affect each other. Experience in any of the following areas is plus: engineering design/CAD, software engineering in C++, embedded programming, control systems.

Contact: Professor Matei Ciocarlie, mtc2103@columbia.edu

Opportunities

- nanoelectromechanical systems (NEMS)
- carbon nanotubes: synthesis, device fabrication, and applications
- nanotechnology for solar energy and fuel cells
- nanofabrication for biological applications

Activities include a variety of experimental work, including nanofabrication, materials synthesis, and electronic/mechanical texting, in the four areas listed above. A commitment of 10 hours per week term-time and 20–35 hours per week during the summer is expected. Students interact with graduate students, faculty, and staff. The opportunity may provide academic credit *(MECE E3900)* or hourly wages during the summer.

Contact: Professor James Hone, jh2228@columbia.edu, 240 Mudd, 212-854-6244

Opportunities

- mechanics and morphogenesis of biological tissues in developing embryos
- design of instrumentation for micromechanical measurements on cells and tissues
- confocal fluorescence imaging of cells and tissues *in vivo*
- development of image analysis software for quantifying cell and tissue movements

Opportunities for undergraduates to work on biological tissue mechanics and morphogenesis in developing embryos or in cultured tissues. Both experimental and computational opportunities are available. Laboratory skills, experience working with *Drosophila* or with tissue culture, and/or experience with MATLAB are a plus. Possible academic credit or remuneration with a commitment of 12 hours per week term-time and full time during the summer.

Contact: Professor Karen Kasza, kk3113@columbia.edu

Opportunities

- mechanical properties of nanoscale materials
- fabricate nanocomposite materials
- biomedical research related to hearing disorders

Opportunities exist for laboratory studies to measure the mechanical properties of nanoscale materials, develop composite materials based upon graphene and other two-dimensional materials, and perform experiments to study the fundamentals of plasticity in metals. In addition, opportunities exist to study how to introduce perforations into the round window membrane that separates the middle ear and the inner ear. Students can participate for academic credit or for financial remuneration Minimum time requirement is 10 hours per week during the academic year and more during the summer.

- nanoporous metals with applications to sensing and actuation
- mechanical properties of nanocrystalline thin films
- fracture and deformation phenomena

Opportunities exist to be involved with laboratory work to develop novel nanostructured materials for use in active devices as well as to understand the mechanics of material deformation and failure at the micrometer and nanometer length scales. Students can participate for academic credit or for financial remuneration. Minimum time requirement is 10 hours per week during the academic year and more during the summer.

Contact: Professor Jeffrey Kysar, jk2079@columbia.edu, 244 Mudd, 212-854-7432

Opportunities

- 3D printing of food (hardware and software development)
- 3D printing of electronics (hardware and software development)
- soft robotics (hardware and software development)
- deep learning (applications to robotics and data mining)
- robotics/AI: any idea you want to explore!

Research opportunities are available year-round (both semesters and summer) for academic credit. Experience in either software or hardware development recommended, but not required. Project can be done individually or in pairs.

Contact: Professor Hod Lipson, hod.lipson@columbia.edu

Opportunities

- data visualization for energy using software and sensing
- programming cell phones for data gathering/monitoring/payments
- integration for sensing, computation, and control on microprocessors

These opportunities involve one or more of analysis, computer programming, database management, data visualization, and library research. They may carry academic credit and/or remuneration, possibly through the Federal Work-Study Program. The weekly time commitment is 10 hours per week term-time and 20–35 hours in the summer. Long-term involvement of at least two semesters and a summer is desirable.

Contact: Professor Vijay Modi, modi@columbia.edu, 220 Mudd, 212-854-2956

Opportunities

- material characterization of soft biological tissue
- biochemical analysis of soft tissue
- fabrication and design of mechanical testing instrumentation and fixtures

Opportunities exist for juniors and seniors to participate in experimental biomechanics research. Research projects include material characterization, engineering design, and biochemical analysis. During the semester, a commitment of 10 hours per week is required for academic credit. During the summer, paid opportunities are available for full- or part-time work.

Contact: Professor Kristin Myers, kmm2233@columbia.edu, 220 Mudd, 212-854-2957

Opportunities

- material characterization, processing, and synthesis
- focus on treatment and analysis of biomaterials and other biological material

Two major projects are available. The first is related to understanding of the underlying phenomena responsible for the alteration of the chemical composition of tissues undergoing disease development and progression. Specifically, vibrational spectroscopy is utilized to investigate functional groups and bonding types in such materials, which provides information about the alteration of the tissue composition on a molecular level. The second research area addresses structural changes of transparent dielectrics and biomaterials under ultrafast laser irradiation. Treating materials over femtosecond time scales results in locally enhanced absorption. This enables processing of the interior of bulk specimens without affecting their surfaces at different length scales. Research is offered for academic credit only. Motivation to perform high-quality research is the main requirement. This opportunity is available during term-time and summer. Weekly hour commitments vary and are subject to agreeement between the advisor and the student.

Contact: Professor Sinisa Vukelic, sv2147@columbia.edu, 220 Mudd, 212-854-3078

Opportunities

- laser micromachining and laser shock processing
- laser forming
- nontraditional manufacturing

Paper study, analytical and experimental work, and computer analysis. A minimum time commitment is 10 hours per week, more in the summer, which may entail academic credit and/or work-study eligibility.

Contact: Professor Y. Lawrence Yao, yly1@columbia.edu, 248 Mudd, 212-854-2887

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