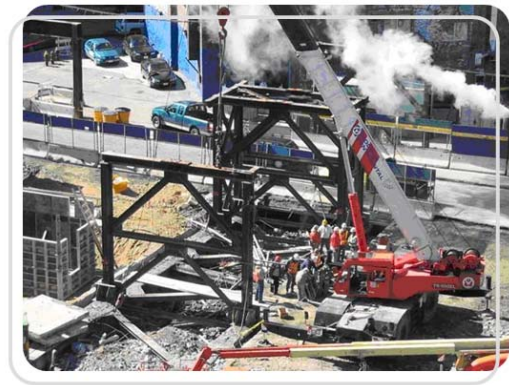




TUFTS UNIVERSITY

Department of Civil and Environmental Engineering



CEE GRADUATE PROGRAM HANDBOOK

2008-2009

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Civil and Environmental Engineering at Tufts University

The Department of Civil and Environmental Engineering (CEE) at Tufts University, with twenty-one full-time faculty is one of the premier CEE departments in the country.. Tufts CEE distinguishes itself from other programs by its interdisciplinary focus and the integrative nature of its graduate education within an intellectually rich environment of a top ranking undergraduate institution.

The mission of the Civil and Environmental Engineering (CEE) Department is to educate civil and environmental engineering students to become leaders in identifying and solving important societal problems of the twenty-first century. Technically rigorous and broad in scope, our programs focus on the interactions between the natural and built environments. CEE programs make extensive use of information technology for managing complex systems and for integrating the teaching, research, and design components of engineering education. Our program breadth includes linkages between engineering disciplines such as environmental, geotechnical, and chemical engineering as well as structural, mechanics, and biomedical engineering. Examples of interdisciplinary studies include architecture, geology, chemistry, environmental policy, and law and diplomacy.

The Civil and Environmental Engineering graduate program consists of degree programs in environmental health, environmental and water resources engineering, geotechnical/geoenvironmental engineering, infrastructure engineering, structural engineering, and mechanics. The broad scope of our graduate program provides students with unique opportunities to specialize in areas best suited for their background and research interests. Depending on their backgrounds and undergraduate degrees, students can work toward Master of Science (M.S.), Master of Engineering (M.Eng.), and Doctor of Philosophy (Ph.D.) degrees. Students are typically selected on a full time basis, though part time enrollment for master's degree students is possible for qualified individuals.

The CEE Department has active and growing research programs. These are exciting times in the Department. Please visit our web page for additional information and feel free to contact us for exciting graduate opportunities.

1. Graduate Programs in Civil and Environmental Engineering

1.1. Graduate Degree Programs

Environmental and Water Resources Engineering provides students with theoretical and practicable knowledge necessary for the stewardship of environmental and water resources. Faculty conduct research in and teach classes on: environmental/water quality engineering; environmental hydrology and hydraulics; environmental statistics; environmental field measurements; groundwater, environmental remediation, natural hazards, hydrogeology; systems engineering; environmental economics; humanitarian engineering, watershed management and integrated water resources management. *Program Director: Shafiqul Islam*

Environmental Health stresses an interdisciplinary approach to current and classical environmental health problems as they manifest themselves in society. Students study environmental pollutants, toxicology, the epidemiological aspects of infectious and chronic diseases, the use of biostatistics in the description of the distribution of disease, the effects of occupational exposures, and the applications of these context areas in the practice of environmental risk management. *Program Director: David Gute*

Geotechnical and Geoenvironmental Engineering integrate experimental, theoretical, and design basics with professional practice issues. The geotechnical engineering program includes course work and research on building foundations, earth support systems, geohazards (earthquakes and landslides), and subsurface environmental problems. The program attracts both civil engineering graduates and students with backgrounds in the natural and physical sciences. Continuing education by practitioners on a part-time basis is strongly encouraged. *Program Director: Lewis Edgers*

Structural Engineering, Mechanics and Materials involves the planning, analysis, design, and health monitoring of buildings, industrial facilities, bridges, and other structures. Mechanics of materials is centered on experimental characterization, mathematical models and numerical simulations of material behavior of soft biological tissues and engineered materials. The program provides students with instruction in mathematics, mechanics, analysis, design, computational methods, and laboratory experience as well as exposure to ongoing research projects. Graduates are well prepared to work in design, analysis and related fields. *Program Director: Masoud Sanayei*

Infrastructure Engineering integrates geotechnical and structural engineering to address problems which cross the interface between these disciplines. Application areas include the design of buildings, bridges, excavation support systems, tunnels, pipelines, transmission line towers, etc. *Program Directors: Lewis Edgers and Masoud Sanayei*

1.2 Interdisciplinary, Certificate, and Continuing Education Programs

Water: Systems, Science and Society (WSSS) interdisciplinary certificate program is offered to CEE MS and Ph.D. students. This program educates a new kind of professional who understands the causes and dynamics of water-related problems from multiple points of view, yet has the skills to be an expert in one discipline. As educators and leaders, such individuals will be able to anticipate and respond to emerging water-related problems, and work with others to develop and implement long-term solutions. Tufts schools participating in the WSSS program include Arts and Sciences, Engineering, Medicine,

Veterinary Medicine, the Friedman School of Nutrition and Policy, and the Fletcher School of Law and Diplomacy (see section 6 and <http://www.tufts.edu/water> for more details). CEE Faculty Advisor: Paul Kirshen

Certificate Program in Environmental Management advanced certificate is offered, on a part-time basis, to qualified students seeking professional training in this critical area where business and management sense intersect with environmental technology and engineering. The Certificate Program in Environmental Management provides students with the tools and techniques they need to understand, manage, and solve complex environmental problems. It builds on the strength of existing Tufts programs. The program can be completed entirely in the evening. *CEE Faculty Advisor: Anne Marie Desmarais*

Certificate Program in Epidemiology is a graduate-level program offered to individuals interested in advanced training in epidemiology. Courses are offered by the Medical School and the School of Nutrition in addition to the School of Engineering. The certificate program for each student is individualized; so many different focus areas in epidemiology can be accommodated. Students may apply for full or part time status. Applications are considered on a rolling basis throughout the year. The Certificate in Epidemiology requires the completion of five classes and can be completed using only evening courses. *CEE Faculty Advisor: Mark Wooden*

Joint and Dual Programs with the department of Urban and Environmental Policy are available for students interested in the study of environmental engineering and environmental policy. CEE Faculty Advisor: David Gute

Continuing Education The Graduate Special Student Program, administered by the Office of Professional and Continuing Studies, allows students with a bachelor's degree who are not matriculated in a degree program to enroll for credit in regular Tufts courses. Students pursuing this option may take courses during the academic year and the summer, and may find it useful for becoming acquainted with the civil and environmental engineering department; beginning course work in anticipation of entering a degree program; or strengthening their academic record. *CEE Graduate Coordinator: Laura Sacco*

If you are uncertain if a graduate degree is for you, we invite you to take courses through the Graduate Career Advancement Program, (GCAP). Up to four of these courses can be applied toward a degree. For more information call the Office of Professional and Continuing Studies at (617) 627-3395.

1.3 Degrees Offered

Master of Science

A Master of Science is awarded in each of the degree programs described in this handbook. Students must complete the course of study outlined for their chosen specialization. There is no foreign language requirement. The program is designed for individuals who desire to pursue doctoral education and research or a career in engineering practice within the private or public sector.

Master of Science programs culminate with the preparation and defense of a thesis. Thesis research is considered an essential part of the degree and constitutes two of the required ten course credits. Detailed program requirements are presented in Section 4 of this handbook.

Master of Engineering

The Master of Engineering program provides a practice oriented alternative to the Master of Science programs offered by the Department of Civil and Environmental Engineering. It responds to the need to provide engineering students with advanced level expertise in a civil and environmental engineering specialty, some technical breadth in a related specialty, familiarity with business and/or legal issues in engineering practice, and a substantial engineering project experience. The program is designed for individuals who desire to pursue a career in engineering practice within the private or public sector. We strongly encourage continuing education by engineering practitioners on a part-time basis. The program provides substantial technical depth beyond the Bachelor's degree and offers a number of unique features.

The Master of Engineering is offered in Geotechnical and Geo-environmental Engineering, Infrastructure Engineering, Structural Engineering and Mechanics, and Environmental and Water Resources Engineering. The degree requirements are described in Section 4 of this handbook.

Doctor of Philosophy

The Ph.D. is the highest level of study and requires a very serious academic commitment. Graduates of the doctoral program are well positioned for careers in academia, industry, government and consulting. Students who have excellent academic backgrounds and demonstrated capability for independent research are encouraged to apply to the doctoral program. Areas of study include Environmental Health, Environmental and Water Resources Engineering, Geotechnical and Geoenvironmental Engineering, and Structural Engineering and Mechanics.

Students entering the doctoral program in civil and environmental engineering are expected to meet the general admission requirements of the graduate school; gain acceptance into the Department of Civil and Environmental Engineering; and hold a bachelor's or master's degree in engineering or a related field. Students are required to complete a minimum of fifteen credits beyond the baccalaureate level. Students entering the program with a Master of Science degree are required to complete a minimum of seven credits. Detailed degree requirements are presented in Section 5 of this handbook.

2. Application and Admissions Information

2.1 Application for Graduate Studies

Students interested in full- or part-time study are encouraged to apply. Our students have varied backgrounds; some have just finished their undergraduate education, others are professionals looking to enhance their knowledge or change careers. Graduate programs in civil and environmental engineering are enhanced by the diverse educational backgrounds of our students. Thus, the *minimum* requirement for graduate study in civil and environmental engineering is a bachelor's degree.

Applications deadlines for graduate study in the Department of Civil and Environmental Engineering at Tufts University are shown below.

	Degree Programs	Fall Matriculation	Spring Matriculation
Domestic Applicants	M.Eng., M.S., Ph.D.	15 January	15 September
International Applicants	M.Eng., M.S., Ph.D.	30 December	15 September

How should I Apply?

Applications and additional information are available on the Graduate and Professional Studies website (<http://www.ase.tufts.edu/GradStudy>). Alternatively, you may contact the Graduate and Professional Studies office at the following location:

Graduate and Professional Studies
Office of Admissions
Ballou Hall
Tufts University
Medford, MA 02155
(617) 627-3395

2.2 Admission Process

After the complete application is received, the application will be reviewed by faculty in the area of study requested by the applicant. The faculty first determines if the applicant's background is acceptable. The faculty must also determine the availability of an advisor and the resources needed to support the graduate student. On this basis, the faculty recommends approving or disapproving the application. The faculty then makes recommendations on financial assistance for acceptable applicants.

Students entering the M.S. or Ph.D. program in civil and environmental engineering are expected to meet the general admission requirements of the graduate school and gain acceptance to the Department of Civil and Environmental Engineering. The latter occurs during the application process and is based upon a careful review of the applicant's background. Admission into the Department generally requires course credits in science (biology, chemistry, physics), mathematics (through differential equations), and engineering sciences (fluid mechanics, statics). Students admitted to the Environmental and Water Resources Engineering program are expected to have also completed at least one semester of college-level probability and statistics. Students admitted for M.S. in Environmental Health should also possess a suitable background in the biological and health sciences. Please note that students lacking one or more of these

undergraduate preparations may be admitted on the condition that they complete the necessary coursework during their first year at Tufts. Credits resulting from the successful completion (i.e., a grade of B or better) of conditional coursework are required to obtain a degree but may not be used to satisfy graduate course requirements within the degree program.

Decisions of the faculty are reviewed and confirmed by the Department Chair. A letter from the Department Chair announcing the decision and detailing the subsequent actions required is mailed to the applicant. The accepted applicant is required to sign and return a form letter to indicate acceptance of the offered admission and to indicate that the conditions of the acceptance are understood. Offers of admission or of admission with financial assistance which are not accepted by the applicant in a timely manner will be withdrawn.

Admission to the graduate programs of the Department of Civil and Environmental Engineering is competitive: not all applicants who satisfy the minimum requirements for admission can be accepted. Decisions on admission are based on credentials furnished in the application package. Financial aid decisions are based on those credentials and on the request for assistance indicated on the application forms. Decisions on admission and financial aid must also consider the availability of advisors, other departmental resources and funding to support the student.

2.3 Full- or Part-time Study

The curricula for master's degrees within the Department of Civil and Environmental Engineering are designed so that full-time students may complete their course work in one to two calendar years. Please note that the actual duration of study depends upon the focus and determination of the student, as well as the selected degree program (M.S. degrees typically take two years to complete). Part-time students enrich the programs by bringing valuable real-life experiences to the classroom. Some courses are offered in the early morning, late afternoon, or evening to accommodate working students. Part-time students can complete their master's studies within two to four years, depending on the individual's course load and degree requirements.

The Graduate Student Handbook for Tufts Arts, Sciences, and Engineering is posted at (http://www.tufts.edu/gradstudy/webcm/docs/2007_2008_graduate_student_handbook.pdf). It provides the following information related to enrollment status. Graduate students are responsible for maintaining proper enrollment status at Tufts. Federal regulations require students to be enrolled (registered) full-time or half-time in order to *receive* and/or *defer* student loans. Tufts provides information regarding student enrollment status to lenders via the National Student Loan Clearinghouse and is required by law to return funds for students who do not maintain proper enrollment status. Enrollment status is either full-time, half-time, or part-time as defined below:

Full-time: 3 or more course credits; 2 course credits and a teaching or research assistantship (must also register for full-time continuation 402 or 502); or registration as a full-time continuing student (402/502) working on a thesis, dissertation, project, or internship.

Half-time: 2 course credits; 1 course credit with a teaching or research assistantship.

Part-time: One course credit or registration as a part-time continuing student (401/501).

3. Matriculation and Registration

A student will normally matriculate (initially enroll) in a degree program only once, but must register each semester in which course will be taken. Generally, a new student should expect to arrive a minimum of one week prior to the start of classes. There are several activities, such as orientation programs, which are necessarily scheduled before the start of classes. International students are encouraged to arrive earlier in order to have ample time to arrange living accommodations, establish financial accounts, become familiar with the region and adjust to the cultural environment.

3.1 Matriculation Process

Upon arrival on the Tufts campus, the entering new student should:

- a) arrange to meet with his/her academic advisor as well as the advisor for their research assistantship (RA) or teaching assistantship (TA), if appropriate
- b) visit the CEE Main Office to obtain necessary forms, verify dates and locations of orientation and other required activities, and receive supplemental information on the matriculation and registration processes.

3.1.1 Orientation Programs. Both the School of Engineering and the Department of Civil and Environmental Engineering schedule mandatory orientation programs for students entering in late August or early September. Failure to attend these programs may jeopardize the student's financial assistance or make registration more cumbersome. Students first entering a graduate program in other semesters must make arrangements to receive pertinent information and orientation on an individual basis. They may be required to attend some or all of the orientation programs in the first August/September following their matriculation.

3.1.2 Meet with Advisor. *Each student should schedule a meeting with his/her academic advisor as soon as possible after arrival on campus. At this meeting, the following points should be discussed:*

- a) The courses to be taken in the first semester of the program.
- b) The duties associated with a Graduate Teaching or Research Assistantship (if student has a TA or RA advisor separate from their academic advisor, they should meet with them as well)
- c) The general plan for completing the program (overall duration, course load, thesis requirements, etc.).
- d) Whether and what credits the student may seek to transfer from other programs.
- e) How often the student should meet with the academic advisor.

3.2 Registration

All new graduate students and those not registered in the preceding semester should obtain Add/Drop forms and advice from their academic advisor. Graduate students are required to consult with their academic advisor and obtain approval of the schedule each semester before registering.

4. Master's Degree Program Requirements

The Department of Civil and Environmental Engineering offers programs of study leading to both a Master of Science and Master of Engineering. A description of these degrees is available in Section 1.3 of this handbook. In brief, the M.Eng. programs are practice-based degrees and M.S. programs contain elements of both theory and practice,. Both master's degrees require successful completion of ten (10) course credits.

4.1. Overview of Study

4.1.1. Master of Engineering. Students are admitted to a specific program of study and assigned an advisor. While most students enter in the fall, it is possible to begin your studies starting in the spring semester. Orientation, however, occurs once a year in late August or early September. All M.Eng. programs require students to complete a master's project addressing a substantial engineering problem. These projects may relate to engineering design, construction, management, operations and/or planning. Students who are practicing engineers are encouraged to consider projects relevant to their own work. A written report and an oral presentation are required. In general it is possible to complete an M.Eng. in one year, however, some students prefer to spend one and half years of full-time study. M.Eng. degrees are well suited to part-time study, with many courses offered in the early morning, late afternoon, or evening.

4.1.2. Master of Science. Students are admitted and matched with an academic / research advisor. Many M.S. students receive offers of support in the form of teaching or research assistantships. Teaching assistantships are extended by the department and hold the expectation that you will support a given course or courses (see Appendix B). Research assistantships are extended by prospective advisors, and hold an expectation that you will support the research project(s) of that faculty member (see Appendix B).

M.S. students are required to complete a thesis. The topic of the thesis is typically selected to be synergistic with the research of a particular faculty member. **Students are expected to form a thesis committee and present a thesis proposal to their committee within twelve (12) months of entering the M.S. program.** M.S. thesis committees should be composed of at least three members, with the chair being the student's advisor within the department. In addition, one of the committee members may be from outside the Department of Civil and Environmental Engineering. While it is acceptable to select committee members from outside the university, the majority of the committee must comprise members of the Faculty at Tufts University.

Thesis research culminates in an oral defense which is open to the public. **M.S. students must defend their thesis no sooner than six (6) months after the first thesis proposal meeting.** The thesis will be prepared in the format specified in the Arts, Science and Engineering Graduate Student Handbook; however, a main section of the thesis should take the form of a peer-reviewed journal article. M.S. students are expected to submit at least one manuscript to a peer-reviewed journal before being cleared to graduate.

4.2. Academic Progress

The Arts, Science and Engineering Graduate Student Handbook is posted at (<http://ase.tufts.edu/gradstudy/GSAShdbk.pdf>). It describes the following policy regarding academic progress. It is expected that a student will complete all courses taken for credit with the grade of B- or better. Courses for which a student receives a grade of less than B- may be retaken only once. The original grade earned remains in the student's record. If a student receives any two grades less than B-, the department will recommend to the graduate dean that the student be administratively withdrawn. Courses for degree or certificate credit may not be taken or transferred as Pass/Fail.

Failure to meet the grade requirements constitutes evidence that the student is making inadequate degree progress and is no longer in good academic standing – and that he/she will be administratively withdrawn unless an exception is granted by the graduate school based on the recommendation from the appropriate department or departmental committee. Only the deans of the Graduate School of Arts and Sciences and the School of Engineering may administratively withdraw an enrolled graduate student. If a course is repeated, the original grade will remain on the transcript. The new grade will be entered under the appropriate semester.

Dismissal from the university can occur for the following reasons:

- academic dishonesty (Tufts' policy for academic integrity is available online at: <http://studentservices.tufts.edu/dos/publications.htm>)
- evidence that degree requirements will not be met within stated time limits
- excessive number of grades below B-

In general, all credits to be counted toward a master's degree must be earned within five calendar years. Exceptions to this time frame include extensions, leave of absences, and reinstatements. Students who require an exception are advised to consult the Arts, Sciences and Engineering Graduate Student Handbook (<http://ase.tufts.edu/gradstudy/GSAShdbk.pdf>) for more information.

4.3. Degree Program Requirements

Program	M.S.	M.Eng.
Environmental Health (EH)	page 10	N/A
Environmental & Water Resources Engineering (EWRE)	page 12	page 20
Geotechnical & Geoenvironmental Engineering (GGE)	page 14	page 22
Infrastructure Engineering (IE)	page 16	page 23
Structural Engineering (SE)	Page 18	page 24

Environmental Health, Master of Science

The Master of Science in Environmental Health stresses an interdisciplinary approach to current and classical environmental health problems as they manifest themselves in society. Students study environmental pollutants, toxicology, the epidemiological aspects of infectious and chronic diseases, the use of biostatistics in the description of the distribution of disease, the effects of occupational exposures, and the applications of these context areas in the practice of environmental risk management.

Requirements:

A. Core Courses (five credits)

- CEE 154 – Principles of Epidemiology
- CEE 173 – Health Effects and Risk Assessment
- CEE 158 – Occupational and Environmental Health
- BIO 132 or MPH 205 – Biostatistics*
- CEE 292R – Research Methods in Environmental Health

*Another biostatistics or environmental statistics course may be substituted with the permission of the student's major advisor and thesis committee.

B. Thesis (two credits) - The M.S. thesis is the culmination of concentrated study in a specific area of research within environmental health. Thesis work contributes two course credits toward the M.S. degree (CEE-295 and CEE-296).

C. Tracks (three credits) - All Environmental Health M.S. students must select either the Epidemiology or the Risk Assessment track. Students must take the required advanced course in the track, and then select two other courses as track electives. At least one of the courses must be from the track elective list; the other can be a course from the other track elective list, from the supplemental list of courses, or another course that the student feels will meet his/her needs. All electives must be approved by the academic advisor.

Epidemiology Track:

Advanced Course (required):

CEE 164 – Epidemiological Methods

Track Electives (choose two):

- CEE 167 – Environmental Toxicology
- MPH 224 – Infectious Disease Epidemiology
- MPH 226 – Cancer Epidemiology
- MPH 240 – Environmental Epidemiology
- MPH 206 - Intermediate
Biostatistics:Regression Methods
- MPH 220 – Cardiovascular Epidemiology
- MPH 222 – Survey Research Methods & Data
Management
- CEE 241/MPH241 – Biology of Water and
Health

Other courses may be selected with the approval of the student's advisor.

Risk Assessment Track:

Advanced Course (required):

CEE 168 – Exposure Assessment

Track Electives (choose two):

- CEE 167 – Environmental Toxicology
- CEE 143 – Site Remediation
- CEE 175 – Hazardous Material Safety
- CEE 194A – Risk Communication and
Public Participation
- CEE 113 – Groundwater Hydrology
- CEE 172 – Fate and Transport of
Environmental Contaminants
- CEE 241/MPH 241 – Biology of Water and
Health
- CEE 136 – Air Pollution Control
- UEP 294B – Chemicals, Health, and
Environment

Other courses may be selected with the approval of the student's advisor.

Environmental Health, Master of Science (continued)

Supplemental Electives List - Other courses of interest to EH MS students include the following. You may substitute one of these courses for one of your track elective with your advisor's approval. This list is not all-inclusive, and you may take other courses relevant to your track and program interests with your advisor's approval.

- CEE/UEP 207 – Environmental Law
- CEE/UEP 265 – Corporate Management of Environmental Issues
- UEP 294G – Geographic Information Systems
- CEE/UEP 267 – Methods in Environmental Impact Assessment
- CEE/UEP 230 – Negotiation, Mediation, and Conflict Resolution
- CEE 136 – Air Pollution Control
- UEP 203 – Political Economy, Ethics, and Environment
- CEE 138 – Hazardous Waste Treatment Technology
- CEE 212 – Chemical Principles for Environmental and Water Resources Engineering
- CEE 213 – Transport Principles for Environmental and Water Resources Engineering
- CEE 214 – Environmental and Water Resources Systems Engineering

D. Graduate Environmental Seminar (no credit) – Every student in the Environmental Health graduate program is required to attend and participate in the weekly seminar series. Each M.S. student is required to give at least one presentation related to their research in this seminar series during their graduate studies.

Faculty Contacts

Associate Professor David M. Gute, *Environmental and Occupational Epidemiology*

Lecturer Anne Marie Desmarais, *Environmental Health*

Senior Lecturer Mark Woodin, *Epidemiologic Methods*

Environmental and Water Resources Engineering, Master of Science

The Master of Science in Environmental and Water Resources Engineering provides students with theoretical and practicable knowledge necessary for the stewardship of environmental and water resources. The program prepares engineers and scientists for careers focusing on the interdisciplinary aspects environmental and water resources. The curriculum is designed to integrate issues of water quality and quantity, and provides students with an opportunity to create an individualized area of concentration.

Requirements:

A. Prerequisites – Students admitted to the Environmental and Water Resources Engineering program are expected to have completed the following courses in natural sciences (biology, chemistry, and/or physics), mathematics (calculus through differential equations), and engineering science (fluids and probability and statistics). Students lacking one or more of these undergraduate preparations may be admitted on the condition that they complete the necessary coursework during their first year at Tufts. Credits resulting from the successful completion (i.e., a grade of B or better) of conditional coursework are required to obtain a degree but may not be used to satisfy graduate course requirements within the degree program.

B. Core Courses (three credits) – The three core courses listed below are designed to provide students with foundation necessary to integrate knowledge of the processes controlling the quantity and quality of water within the planning, design, and management of complex environmental and water resource systems.

CEE 212 – Environmental Chemistry (fall semester)

CEE 213 – Principles of Transport and Reaction in the Environment (fall semester)

CEE 214 – Environmental and Water Resources Systems Engineering (spring semester)

C. Concentration Courses (three credits) – These courses enable students to study areas of particular interest in greater depth. Students may select any three of the following courses, in consultation with his/her advisor, to satisfy the concentration requirement. Note that students opting for a M.Eng. project are required to take four concentration courses.

CEE 103 – Water Quality Modeling (Spring*)

CEE 112 – Hydrology and Water Resource Engineering (Fall)

CEE 113 – Groundwater Hydrology (Fall)

CEE 131 – River Hydraulics and Restoration (Fall*)

CEE 132 – Environmental Engineering Processes (Spring semester)

CEE 133 – Water and Wastewater Plant Design (Spring)

CEE 134 – Water and Wastewater Chemistry (Fall)

CEE 139 – Bioremediation: Natural and Enhanced (Spring*)

CEE 143 – Site Remediation (Spring)

CEE 152 – Engineering Systems – Stochastic Systems (Spring*)

CEE 172 – Fate and Transport of Environmental Contaminants (Spring*)

CEE 194L – Introduction to Industrial Ecology (Spring*)

CEE 202 – Environmental Statistics (Fall*)

CEE 239 – Physiochemical Processes in Water and Wastewater Treatment (Fall*)

CEE 241 – Biology of Water and Health (Fall)

CEE 293A – Environmental Signal Processing (Fall*)

CEE 293B – Water: Constraints, Conflicts, and Cooperation at Boundaries (Fall*)

Environmental and Water Resources Engineering, Master of Science (continued)

Possible concentration courses (continued)

CEE 294AR – Transport in Porous Media (Spring)

CEE 294K – Integrated Water Resources Management (Fall)

CEE-0294W Water: Systems, Science, and Society (WSSS) Research Practicum (Spring)

GEO 187 – Subsurface Fluid Dynamics (Spring*)

GEO 188 – Groundwater Modeling (Spring*)

GEO 189 – Geofluids (Fall*)

ES 101 – Numerical Methods (Fall)

*course is offered every other year

D. Thesis (two credits) – The M.S. thesis is the culmination of concentrated study in a specific area of research within environmental and water resources engineering. Thesis work contributes two course credits toward the M.S. degree (CEE-295 and CEE-296).

E. Elective Courses (two credits) – Electives are designed to provide greater breadth or depth in areas related to the student's research topic. The only restriction placed on these two electives is that they be recognized (i.e., approved) by the student's M.S. committee as being relevant to the chosen research topic. Note that in some scenarios committee approval may occur subsequent to completion of an elective course. Students wishing to take an elective course prior to identifying thesis committee members are strongly encouraged to obtain the approval of their *thesis* advisor before registering for the course.

F. Graduate Environmental Seminar (no credit) – Every student in the Environmental and Water Resources graduate program is required to attend and participate in the weekly seminar series. Every student must enroll in CE-291/292 Graduate Seminar during each of the Fall and Spring semesters. Each M.S. student is required to give at least one presentation related to their research in this seminar series during their graduate studies.

Faculty Contacts

Professor Linda M. Abriola, *Multiphase Flow Modeling, Groundwater Restoration*

Professor Steven C. Chapra, *Water Quality Modeling*

Professor Shafiqul Islam, *Hydrometeorology and Hydroclimatology, Remote Sensing and Scale Issues, Water Conflicts and Diplomacy*

Professor Richard M. Vogel, *Water Resource Systems, Environmental Statistics, Hydrology and Hydraulics*

Professor Grant Garven, Department of Geology, *Groundwater Geology and Hydrology*

Associate Professor Wayne Chudyk, *Drinking Water Quality and Toxic Materials, Groundwater Monitoring*

Associate Professor John L. Durant, *Contaminant Fate and Transport*

Associate Professor Stephen H. Levine, *Systems Engineering, Industrial Ecology*

Associate Professor Christopher W. Swan, *Groundwater Engineering, Geoenvironmental Engineering*

Assistant Professor C. Andrew Ramsburg, *Subsurface Transport Phenomena, Development of Innovative Remediation Technologies*

Research Professor Paul Kirshen, *Water Resources Systems Planning and Management*

Lecturer Anne Marie Desmarais, *Risk Assessment, Site Remediation*

Geotechnical and Geoenvironmental Engineering, Master of Science

The Geotechnical and Geoenvironmental Engineering program integrates experimental, theoretical, and design basics with professional practice issues. The geotechnical engineering program incorporates course work and research on (earthquakes and landslides) building foundations, earth support systems, geohazards, and subsurface environmental problems including: site characterization; waste treatment; waste containment; reuse of waste materials; and the clean-up and reuse of contaminated sites. Graduates are well prepared for successful careers in design, construction, and research, in both the public and private sectors. The curriculum is flexible enough to be attractive to both civil engineering graduates and students with backgrounds in the natural and physical sciences. Continuing education by practitioners on a part-time basis is strongly encouraged.

Course Requirements:

A. Required core courses (five credits)

- CEE-142 Advanced Soil Mechanics
- CEE-145 Computer Methods in Geotechnical Engineering
- CEE-147 Soil Dynamics and Earthquake Engineering
- CEE-244 Laboratory and In-situ Measurement of Soil Properties
- CEE-294 Geotechnical Graduate Seminar (each Spring)

B. Geotechnical / Geoenvironmental Engineering Electives (two credits)

- CEE-143 Site Remediation Techniques
- CEE-146 Foundation Engineering
- CEE-149 Earth Support Systems
- CEE-172 Fate and Transport of Environmental Contaminants

C. Master's Thesis (two credits) – The M.S. thesis is the culmination of concentrated study in a specific area of research within geotechnical / geoenvironmental engineering. Thesis work contributes two course credits toward the M.S. degree (CEE-295 and CEE-296).

D. Technical Electives (one credit) – A maximum of one technical elective selected with the guidance of your advisor. This course may include the geotechnical / geoenvironmental electives above and courses offered by the civil and environmental engineering department and other departments including, but not limited to, geology, mathematics, mechanical engineering, urban and environmental policy, etc.

Possible technical electives include, but are not limited to:

- CEE-102 Probability and Statistics
- CEE-105 Finite Element Analysis
- CEE-106 Structural Dynamics and Earthquake Engineering
- CEE-113 Groundwater Hydrology
- CEE-122 Applied Elasticity
- CEE-125 Advanced Reinforced Concrete Design
- CEE-133 Wastewater Plant Design
- CEE-134 Water and Wastewater Chemistry
- CEE-138 Hazardous Waste Treatment Technology
- CEE-139 Bioremediation: Natural and Enhanced
- CEE-173 Health Effects and Risk Assessment

Geotechnical and Geoenvironmental Engineering, Master of Science (continued)

Possible technical electives (continued)

CEE-193-PS	Applied Probability and Statistics for Engineers
CEE-185	Legal Issues in Engineering Practice
CEE-188	Engineering Design with CAD
CEE-193	Nonlinear Finite Element Method
CEE-193X	Site Investigation Techniques
CEE-201	Land Use Planning and Policy
CEE-202	Environmental Statistics
GEO-32	Geomorphology
CEE/ME-128	Structural Mechanics
ENV-193R	Advanced Geographic Information Systems
ES-101	Numerical Methods
CEE-193G	Introduction to Geographic Information Systems
ME-150	Applied Mathematics for Engineers

Faculty Contacts

Professor Linda M. Abriola, *Multiphase Flow Modeling, Groundwater Restoration*

Professor Lewis Edgers, *Geotechnical and geoenvironmental engineering - geohazards (landslides) and offshore foundations (wind turbines)*

Associate Professor Christopher W. Swan, *Geotechnical and Geoenvironmental Engineering*

Associate Professor Laurie Baise, *Geotechnical, Earthquake Engineering, Geohazards*

Assistant Professor Andrew Ramsburg, *Subsurface Transport Phenomena, Development of Innovative Remediation Technologies*

Infrastructure Engineering, Master of Science

The infrastructure engineering Master of Science program integrates the experimental, theoretical, and design basics of geotechnical and structural engineering to address problems that cross the interface between geotechnical and structural engineering. Application areas include the soil-structure interaction, nondestructive testing of constructed facilities, earthquake engineering, design of buildings, bridges, foundations, excavation support systems, tunnels, pipelines, transmission line towers, etc. Graduates of the program are well prepared to pursue a Ph.D. in infrastructure engineering or work in infrastructure engineering consulting or design, construction, and related fields. The curriculum is flexible enough to allow the widest range of research area in geotechnical, materials, and structural engineering.

Course Requirements

A total of ten course credits must be taken to fulfill the requirements of the Master of Science degree in Infrastructure Engineering. The required courses are six core courses (three geotechnical and three structural), and two elective. In addition, a two-credit thesis must also be completed. A summary of the requirements is given below.

A. Structural Engineering (three credits, take three of four below)

- CEE-105 Finite Element Analysis
- CEE-106 Structural Dynamics and Earthquake Engineering
- CEE-122/128 Advanced Strength of Materials of Structural Mechanics
- CEE-123 Advanced Structural Systems Analysis

B. Geotechnical Engineering (three credits)

- CEE-142 Advanced Soil Mechanics
- CEE-145 Computer Methods in Geotechnical Engineering
- CEE-147 Soil Dynamics & Earthquake Engineering

C. Technical Electives (two credits)

Four technical electives selected with the guidance of your advisor. These courses may include the geotechnical/structural electives and courses offered by the civil and environmental engineering department and other courses including, but not limited to, construction management, mechanical engineering, computer science, mathematics, etc.

Possible technical electives include, **but are not limited to:**

- CEE-105 Finite Element Analysis
- CEE-106 Structural Dynamics & Earthquake Engineering
- CEE-113 Groundwater Hydrology
- CEE-123 Advanced Structural Systems Analysis
- CEE-124 Advanced Steel Design
- CEE-125 Advanced Reinforced Concrete Design
- CEE-126 Structural Stability
- CEE-127 Concrete: Materials and Mechanics
- CEE-129 Bridge Design and Rehabilitation
- CEE-146 Foundation Engineering
- CEE-149 Earth Support Systems
- CEE-185 Legal Issues in Engineering Practice

Infrastructure Engineering, Master of Science (continued)

Possible technical electives (continued)

CEE-188	Engineering Design with CAD
CEE-193G	Introduction to Geographic Information Systems
CEE-223	Analysis and Design of Plates and Shells
CEE-244	Laboratory and In-Situ Measurements of Soil Properties
CE/ME-122	Advanced Strength of Materials
CE/ME-128	Structural Mechanics
ME-123	Mechanics of Composite Materials
CEE-102	Probability and Statistics in Engineering
CEE-193G	Introduction to Geographic Information Systems
ES-101	Numerical Methods
ME-150	Applied Mathematics for Engineers

D. Thesis (two credits) – The M.S. thesis is the culmination of concentrated study in a specific area of research within infrastructure engineering. Thesis work contributes two course credits toward the M.S. degree (CEE-295 and CEE-296).

Faculty Contacts

Professor Lewis Edgers, *Geotechnical and geoenvironmental engineering - geohazards (landslides) and offshore foundations (wind turbines)*

Professor Masoud Sanayei, *Structural Engineering, Finite Element Analysis, Structural Dynamics, Structural Health Monitoring*

Associate Professor Christopher W. Swan, *Geotechnical and Geoenvironmental Engineering*

Associate Professor Laurie Baise, *Geological Engineering, Earthquake Engineering*

Assistant Professor Babak Moaveni, *Structural Engineering, Structural health monitoring, experimental modal analysis, signal processing, uncertainty quantification*

Professor of the Practice, Brian Brenner, *Concrete Design, Bridge Analysis and Design, Structural Analysis/Design and Mechanics*

Professor of the Practice Eric Hines, *Earthquake Engineering, Steel Design, Concrete Design, Structural Systems Design*

Senior Lecturer Lee R. Minardi, *Computer Aided Design, Geometric Modeling, Engineering Mechanics*

Structural Engineering and Mechanics, Master of Science

Structural Engineering is involved in the planning, analysis, design and health monitoring of buildings, bridges, industrial facilities and other structures. Mechanics of materials is centered on experimental characterization, constitutive theories (mathematical models of material behavior) and numerical simulations of soft biological tissues and engineered materials. The graduate program in Structural Engineering, Mechanics and Materials at Tufts University is designed to expose students to fundamental theoretical concepts of mathematics, mechanics as well as practical knowledge of modern structural engineering. This is accomplished through a comprehensive program of instruction in mechanics, analysis, and design as well as significant exposure to research and design projects. Students will be exposed to state of the art numerical methods of analysis and design using the department's modern computer laboratory and to experimental work using the department's materials and structures laboratories. Graduates of this program are well prepared to pursue a Ph.D. in structural engineering or work in structural engineering consulting or design, construction, aerospace, and related fields.

Course Requirements

A total of ten course credits must be taken to fulfill the requirements of the Master of Science degree in structural engineering, mechanics and materials. The required courses are 3 structural analysis courses, at least one course in mechanics of materials, at least one design course, and three elective courses. In addition, a two credit thesis must also be completed.

A. Structural Analysis (three credits)

- CEE-105 Finite Element Analysis
- CEE-106 Structural Dynamics & Earthquake Engineering
- CEE-123 Advanced Structural Systems Analysis

B. Mechanics of Materials (at least one):

- CEE/ME-122 Advanced Strength of Materials
- CEE/ME-128 Structural Mechanics

C. Structural Design (at Least one credit)

- CEE-124 Advanced Steel Design
- CEE-125 Advanced Reinforced Concrete Design
- CEE- Bridge Design and Rehabilitation

D. Mathematics (at least one credit):

- CEE-102 Probability and Statistics in Engineering
- ES-101 Numerical Methods
- ME-150 Applied Mathematics for Engineers

E. Technical Elective (a maximum of three credits) – Courses in structural engineering or in the related fields of geotechnical engineering, construction management, mechanical engineering, computer science or mathematics. In addition to classes listed in sections A through D, these courses may include **but are not limited to the following:**

- CEE-126 Structural Stability
- CEE-146 Foundation Engineering
- CEE-147 Soil Dynamics and Earthquake Engineering
- CEE-149 Earth Support Systems
- CEE-151 Engineering Systems: Deterministic Models
- CEE-152 Engineering Systems: Stochastic Models

CEE-188 Engineering Design with CAD
CEE-193G Introduction to Geographic Information Systems
CEE-193/194 Special Topics
ME-123 Mechanics of Composite Materials
ME-124 Fracture Mechanics
ME-126 Computer-Integrated Engineering
CEE-194N Nonlinear Finite Element Methods
CEE/ME-221 Introduction to Solid Mechanics
CEE/ME-222 Applied Solid Mechanics
CEE/ME-225 Advanced Structural Dynamics
CEE-223 Plates and Shells
EE-102 Linear Systems
EE-124 Signal Processing
ES-101 Numerical Methods
ME-150 Applied Mathematics for Engineers

F. Thesis Research (two credits) – The M.S. thesis is the culmination of concentrated study in a specific area of research within structural engineering. Thesis work contributes two course credits toward the M.S. degree (CEE-295 and CEE-296).

Faculty Contacts

Professor Masoud Sanayei, *Structural Engineering, Finite Element Analysis, Structural Dynamics, Structural Health Monitoring*

Associate Professor Luis Dorfmann, *Structural Engineering, Mechanics of Materials*

Assistant Professor Babak Moaveni, *Structural Engineering, structural analysis, structural dynamics, random vibrations, and parametric identification*

Professor of the Practice Brian Brenner, *Concrete Design, Bridge Analysis and Design, Structural Analysis/Design and Mechanics*

Professor of the Practice Eric Hines, *Earthquake Engineering, Steel Design, Concrete Design, Structural Systems Design*

Senior Lecturer Lee R. Minardi, *Computer Aided Design, Geometric Modeling, Engineering Mechanics*

Environmental and Water Resources Engineering, Master of Engineering

A Master of Engineering in Environmental and Water Resources Engineering provides students with practicable knowledge necessary for the stewardship of environmental and water resources. The program prepares engineers and scientists for careers focusing on the interdisciplinary aspects environmental and water resources. The curriculum is designed to integrate issues of water quality and quantity, and provides students with an opportunity to create an individualized area of concentration.

Requirements:

A. Prerequisites – Students admitted to the Environmental and Water Resources Engineering program are expected to have completed the following courses in natural sciences (biology, chemistry, and/or physics), mathematics (calculus through differential equations), and engineering science (fluids and probability and statistics). Students lacking one or more of these undergraduate preparations may be admitted on the condition that they complete the necessary coursework during their first year at Tufts. Credits resulting from the successful completion (i.e., a grade of B or better) of conditional coursework are required to obtain a degree but may not be used to satisfy graduate course requirements within the degree program.

B. Core Courses (three credits) – The three core courses listed below are designed to provide students with foundation necessary to integrate knowledge of the processes controlling the quantity and quality of water within the planning, design, and management of complex environmental and water resource systems.

CEE 212 – Chemical Principles for Environmental & Water Resources Eng. (fall semester)

CEE 213 – Transport Principles for Environmental & Water Resources Eng. (fall semester)

CEE 214 – Environmental and Water Resources Systems Engineering (spring semester)

C. Concentration Courses (four credits) – These courses enable students to study areas of particular interest in greater depth. Students may select any four of the following courses to satisfy the concentration requirement.

CEE 203 – Water Quality Modeling (Spring *)

CEE 112 – Hydrology and Water Resource Engineering (Fall)

CEE 113 – Groundwater Hydrology (Fall)

CEE 131 – River Hydraulics and Restoration (Fall *)

CEE 132 – Environmental Engineering Processes (Spring)

CEE 133 – Water and Wastewater Plant Design (Spring)

CEE 134 – Water Chemistry (Fall)

CEE 139 – Bioremediation: Natural and Enhanced (Spring *)

CEE 143 – Site Remediation (Spring)

CEE 152 – Engineering Systems – Stochastic Systems (Spring *)

CEE 172 – Fate and Transport of Environmental Contaminants (Spring *)

CEE 194L – Introduction to Industrial Ecology (Spring*)

CEE 202 – Environmental Statistics (Fall*)

CEE 239 – Physiochemical Processes in Water and Wastewater Treatment (Fall *)

CEE 241 – Biology of Water and Health (Fall)

CEE 294AR – Transport in Porous Media (Spring)

CEE 293A – Environmental Signal Processing (Fall *)

CEE 293B – Water: Constraints, Conflicts, and Cooperation at Boundaries (Fall *)

CEE 294K – Integrated Water Resources Management (Fall)

Environmental and Water Resources Engineering, Master of Eng. (continued)

CEE-0294W Water: Systems, Science, and Society (WSSS) Research Practicum (Spring)

GEO 187 – Subsurface Fluid Dynamics (Spring *)

GEO 188 – Groundwater Modeling (Spring *)

GEO 189 – Geofluids (Fall *)

ES 101 - Numerical Methods (Fall)

*course is offered every other year

D. Master's Project (one credit) – M.Eng. project may relate to engineering design, construction, management, operations and/or planning. Students who are practicing engineers are encouraged to consider projects relevant to their own work. A written report and an oral presentation are required for CEE 299.

E. Elective Courses (two credits) – Electives are designed to provide greater breadth or depth in areas related to the student's research topic. The only restriction placed on these two electives is that they be recognized (i.e., approved) by the student's M.S. committee as being relevant to the chosen research topic. Note that in some scenarios committee approval may occur subsequent to completion of an elective course. Students wishing to take an elective course prior to identifying thesis committee members are strongly encouraged to obtain the approval of their *thesis* advisor before registering for the course.

F. Graduate Environmental Seminar (no credit) – Every student in the Environmental and Water Resources graduate program is required to attend and participate in the weekly seminar series. Every student must enroll in CE-291/292 Graduate Seminar during each of the Fall and Spring semesters. Each M.Eng. student is required to give at least one presentation related to an ongoing professional project in this seminar series during their graduate studies.

Faculty Contacts

Professor Linda M. Abriola, *Multiphase Flow Modeling, Groundwater Restoration*

Professor Steven C. Chapra, *Water Quality Modeling*

Professor Shafiqul Islam, *Hydrometeorology and Hydroclimatology, Remote Sensing and Scale Issues, Water Conflicts and Diplomacy*

Professor Richard M. Vogel, *Water Resource Systems, Environmental Statistics, Hydrology and Hydraulics*

Professor Grant Garven, Department of Geology, *Groundwater Geology and Hydrology*

Associate Professor Wayne Chudyk, *Drinking Water Quality and Toxic Materials, Groundwater Monitoring*

Associate Professor John L. Durant, *Contaminant Fate and Transport*

Associate Professor Christopher W. Swan, *Groundwater Engineering, Geoenvironmental Engineering*

Assistant Professor C. Andrew Ramsburg, *Subsurface Transport Phenomena, Development of Innovative Remediation Technologies*

Research Professor Paul Kirshen, *Water Resources Systems Planning and Management*

Lecturer Anne Marie Desmarais, *Risk Assessment, Site Remediation*

Geotechnical and Geoenvironmental Engineering, Master of Engineering

The Geotechnical and Geoenvironmental Engineering program integrates experimental, theoretical, and design basics with professional practice issues. The geotechnical engineering program incorporates course work and research on building foundations, earth support systems, geohazards (earthquakes and landslides), and subsurface environmental problems including: site characterization; waste treatment; waste containment; reuse of waste materials; and the clean-up and reuse of contaminated sites. Graduates are well prepared for successful careers in design, construction, and research, in both the public and private sectors. The curriculum is flexible enough to be attractive to both civil engineering graduates and students with backgrounds in the natural and physical sciences. Continuing education by practitioners on a part-time basis is strongly encouraged.

Requirements:

A. Core Courses (four credits)

- CEE-142 Advanced Soil Mechanics
- CEE-145 Computer Methods in Geotechnical Engineering
- CEE-147 Soil Dynamics and Earthquake Engineering
- CEE-244 Laboratory and In-Situ Measurement of Soil Properties

B. Geotechnical/Geoenvironmental Electives (two credits) – A minimum of two of the following five courses must be selected. Other elective courses may be substituted, subject to the advisor's approval.

- CEE-113 Groundwater Hydrology
- CEE-143 Site Remediation
- CEE-146 Foundation Engineering
- CEE-149 Earth Support Systems
- CEE-172 Fate and Transport of Environmental Contaminants
- CEE-193A Engineering Geology

C. Technical Electives (two credits) – A minimum of two technical design electives to be selected from environmental and water resources engineering or structural engineering. The breadth electives may include CEE-188 Engineering Design with CAD

D. Professional Practice Elective (one credit)

- CEE-185 Legal Issues in Engineering Practice

E. Breadth Elective (one credit)

- CEE-299 Master of Engineering Project or
- Any elective that adds to the breadth of your education

Faculty Contacts

Professor Linda M. Abriola, *Multiphase Flow Modeling, Groundwater Restoration*

Professor Lewis Edgers, *Geotechnical and geoenvironmental engineering - geohazards (landslides) and offshore foundations (wind turbines)*

Associate Professor Christopher W. Swan, *Geotechnical and Geoenvironmental Engineering*

Associate Professor Laurie Baise, *Geotechnical, Earthquake Engineering, Geohazards*

Assistant Professor Andrew Ramsburg, *Subsurface Transport Phenomena, Development of Innovative Remediation Technologies*

Infrastructure Engineering, Master of Engineering

The infrastructure engineering M.Eng. program combines coursework from the existing geotechnical and structural engineering programs to address problems which cross the interface between geotechnical and structural engineering. Application areas include the design of buildings, bridges, foundations, excavation support systems, tunnels, pipelines, transmission line towers, etc. Candidates for the M.Eng. in Infrastructure Engineering must possess an ABET accredited B.S. in Civil Engineering or equivalent. With careful planning, it may be possible to complete the M.Eng. program in Infrastructure Engineering in one calendar year. The detailed course requirements are described below.

Requirements:

A. Geotechnical Core (four credits)

1. Computer Methods in Geotechnical Engineering: CEE-145
2. Soil properties: CEE-142 or CEE-244
3. Two geotechnical electives selected from:
 - CEE-113 Groundwater Hydrology
 - CEE-143 Site Remediation
 - CEE-146 Foundation Engineering
 - CEE-147 Soil Dynamics and Earthquake Engineering
 - CEE-149 Earth Support Systems
 - CEE-193A Engineering Geology
 - CEE-142 or CEE-244
 - CEE-102 Probability and Statistics or CEE-188 Eng. Design with CAD

B. Structural Core (four credits)

1. Structural Analysis/FEM: CEE-105 or CEE-123
2. Strength of Materials/Solid Mechanics: CEE/ME-122 or CEE/ME-128
3. Structural design: CEE-124, CEE-125, or CEE-129
4. One structural elective selected from: 1-3 above or
 - CEE-106 Structural Dynamics and Earthquake Engineering
 - CEE-126 Structural Stability
 - CEE-223 Analysis and Design of Plates
 - CEE-102 Probability and Statistics or CEE-188 Eng. Design with CAD

C. Professional Practice Elective (one credit)

CEE-185 Legal Issues of Engineering

D. Breadth Elective (one credit)

CEE-299 Master of Engineering Project **or**
Any elective that adds to the breadth of your education

Faculty Contacts:

Professor Lewis Edgers
Professor Masoud Sanayei
Associate Professor Christopher W. Swan
Associate Professor Luis Dorfmann
Associate Professor Laurie Baise
Assistant Professor Babak Moaveni
Professor of the Practice Brian Brenner
Professor of the Practice Eric Hines
Senior Lecturer Lee R. Minardi

Structural Engineering and Mechanics, Master of Engineering

The Master of Engineering in Structural Engineering Program incorporates depth in a balanced course distribution in structural analysis, mechanics, and design with breadth in geotechnical engineering, hydraulics, or mechanical engineering.

Requirements:

A. Structural Analysis Core (two credits)

CEE-105 Finite Element Analysis
CEE-106 Structural Dynamics and Earthquake Engineering
CEE-123 Advanced Structural Systems Analysis

B. Mechanics of Materials (one credit)

CE/ME-122 Advanced Strength of Materials
CE/ME-128 Structural Mechanics

C. Structural Design (two credits)

CEE-124 Advanced Steel Design
CEE-125 Advanced Reinforced Concrete Design
CEE-129 Bridge Design and Rehabilitation

D. Structural Electives (two credits) – Choose courses from A, B or C above or

CEE-126 Structural Stability
CEE-127 Concrete: Material and Mechanics
CEE-223 Analysis and Design of Plates
ME-123 Mechanics of Composite Materials
ME-225 Advanced Structural Dynamics

E. Technical Electives (one credit)

CEE-113 Groundwater Hydrology
CEE-131 River Hydraulics
CEE-143 Site Remediation
CEE-146 Foundation Engineering
CEE-149 Earth Support Systems
ME-123 Mechanics of Composite Materials
ME-124 Fracture Mechanics
CEE-102 Probability and Statistics in Engineering
CEE-188 Engineering Design with CAD
CEE-193G Introduction to Geographic Information Systems
CE/ME-194N Nonlinear Structural Analysis
ES-101 Numerical Methods
ME-150 Applied Mathematics for Engineers

F. Professional Practice Elective (one credit)

CEE-185 Legal Issues of Engineering

G. Breadth Elective (one credit)

CEE-299 Master of Engineering Project **or**
Any elective that adds to the breadth of your education

Structural Engineering, Master of Engineering (continued)

Faculty Contacts

Professor Masoud Sanayei, *Structural Engineering, Finite Element Analysis, Structural Dynamics, Structural Health Monitoring*

Associate Professor Luis Dorfmann, *Structural Engineering, Mechanics of Materials*

Assistant Professor Babak Moaveni, *Structural Engineering*, structural analysis, structural dynamics, random vibrations, and parametric identification

Professor of the Practice Brian Brenner, *Concrete Design, Bridge Analysis and Design, Structural Analysis/Design and Mechanics*

Professor of the Practice Eric Hines, *Earthquake Engineering, Steel Design, Concrete Design, Structural Systems Design*

Senior Lecturer Lee R. Minardi, *Computer Aided Design, Geometric Modeling, Engineering Mechanics*

5. Doctoral Degree Programs

The Ph.D. is a research oriented degree that requires in-depth knowledge of a specific topic of study. Programs of study are highly individualized, but consist of two main components: course work and independent research. Unlike bachelor's degree and some master's degrees, progress toward the doctoral degree is measured by achievement, not time or number of courses completed. That notwithstanding, it is often constructive for planning purposes to consider that it takes *on average* about five calendar years of concentrated study beyond the bachelor's degree to complete the requirements for the doctoral degree. Doctoral-level research leads to fascinating discoveries and novel technologies. While exhilarating at times, a doctoral research project demands steady commitment generated by self motivation and careful planning.

5.1. Overview of Study

Students are admitted to a specific program of study and assigned an advisor. While most students enter in the fall, it is possible to begin your studies starting in the spring term. Orientation, however, occurs once a year in late August or early September. Admission to the doctoral program does not constitute Ph.D. candidacy. Ph.D. candidacy is significant milestone along the path to the doctoral degree, and typically signifies an individual that is prepared to embark upon an individual investigation of a novel research topic. Completion of the subsequent research occurs with the successful, oral defense of one's written dissertation.

5.2. Academic Progress

The Arts, Science and Engineering Graduate Student Handbook is posted at (<http://ase.tufts.edu/gradstudy/GSAShdbk.pdf>). It describes the following policy regarding academic progress. It is expected that a student will complete all courses taken for credit with the grade of B- or better. Courses for which a student receives a grade of less than B- may be retaken only once. The original grade earned remains in the student's record. If a student receives any two grades less than B-, the department will recommend to the graduate dean that the student be administratively withdrawn. Courses for degree or certificate credit may not be taken or transferred as Pass/Fail.

Failure to meet the grade requirements constitutes evidence that the student is making inadequate degree progress and is no longer in good academic standing – and that he/she will be administratively withdrawn unless an exception is granted by the graduate school based on the recommendation from the appropriate department or departmental committee. Only the deans of the Graduate School of Arts and Sciences and the School of Engineering may administratively withdraw an enrolled graduate student. If a course is repeated, the original grade will remain on the transcript. The new grade will be entered under the appropriate semester.

Dismissal from the University can occur for the following reasons:

- academic dishonesty (Tufts' policy for academic integrity is available online at: <http://studentservices.tufts.edu/dos/publications.htm>)
- evidence that degree requirements will not be met within stated time limits
- excessive number of grades below B-

In general, all credits to be counted toward a doctoral degree must be earned within seven calendar years. Exceptions to this time frame include extensions, leave of absences, and reinstatements. Students who require an exception are advised to consult the Arts, Sciences and Engineering Graduate Student Handbook (<http://ase.tufts.edu/gradstudy/GSAShdbk.pdf>) for more information.

5.3. Doctoral Program Requirements

All doctoral programs in the Department of Civil and Environmental Engineering have the following requirements:

A. Complete course work (bachelor's degree + fifteen credits, or master's degree + seven credits) – Courses will be selected to provide the student with an individualized curriculum related to the chosen area of study. Students entering with a bachelor's degree are required to complete the core course for the M.S. program in the selected area of study.

B. Pass a qualifying examination – consists of written and oral components. Passing this exam admits a doctoral student to doctoral candidacy.

C. Pass a proposal defense – consists of an oral evaluation of the proposed doctoral research by the candidate's dissertation committee.

D. Complete dissertation – conduct research as proposed to the dissertation committee. You should seek guidance from your committee members whenever appropriate. It is strongly recommended that you hold committee meetings at least every six months to keep the committee (i.e., as a group and not individually) apprised of your progress.

E. Pass dissertation defense – consists of an oral defense of the dissertation research. This meeting must be open to the public.

F. Submission of final dissertation in accordance with university regulations – see the Arts, Sciences and Engineering Graduate Student Handbook for more information (<http://ase.tufts.edu/gradstudy/GSAShdbk.pdf>).

5.4. Sequence of Events

It is important to recognize that many of these requirements have detailed procedures and specific time frames. This section contains an overview of each requirement as they appear in a temporal progression toward the doctoral degree.

At the **start of a Ph.D.** the department is responsible for the students' welfare and the quality of the Ph.D. experience. The student and the advisor are matched following an interview (this can be done by telephone) and a careful scrutiny of interests. Another important consideration for the matching of students and advisors is the availability of funding. Doctoral students are not typically admitted without support.

Within twelve months of starting the Ph.D. a student must attempt to pass the qualifying exam. Qualifying exams will be offered at the beginning of the fall semester (i.e., it is anticipated that students will take the exam at the start of their second year as a Ph.D. student), and administered by a qualifying exam committee appointed by the program. The qualifying exam will include written and oral components. Potential outcomes include failure, conditional pass, and pass. The student will be informed of the outcome in a meeting with the advisor and in writing by the Department Chair. An outcome of pass will promote the Ph.D. Student to a Ph.D. Candidate. The terms of any conditional pass must be clearly delineated and agreed upon by the examining committee. Students who do not pass the exam are eligible to petition the faculty for permission to re-take the exam. Such petitions can only be made once, and are reviewed and accepted/declined by vote of the program faculty. Students who fail the qualifying exam and do not petition (or who petition and are declined a second opportunity) will be dismissed from the program.

An individualized curriculum plan must be discussed and approved by the student's dissertation committee within twelve months of starting the Ph.D. Formation of the dissertation committee is the responsibility of the student, with the understanding that the committee must comprise at least 4 members, half of which are to be members of the faculty in the Department of Civil and Environmental Engineering at Tufts University. At least one member must be from outside the Department. It is also required that the majority of the committee members be Graduate faculty. Members of the graduate faculty include any full-time faculty member having a doctoral degree. At a minimum, seven credits are required beyond a master's degree.

A dissertation proposal must be presented and approved at least twelve months *before* the dissertation defense. The proposal should be prepared in consultation with the dissertation committee. The Ph.D. proposal should be of a quality suitable for submission to a competitive funding agency. It is very desirable that candidates and advisors actually submit this proposal to a national funding agency. The outcome of the proposal defense is decided by the dissertation committee. Potential outcomes include failure, conditional pass, and pass. Failure of the proposal defense constitutes grounds for dismissal of the candidate. A conditional pass requires that a candidate reconsider the proposal and re-take the proposal defense within six months. Successful completion of the dissertation proposal defense (i.e., an outcome of pass) is a significant milestone towards completion of the Ph.D. degree. In all cases the candidate will be informed of the outcome in a meeting with the advisor and in writing by the Department Chair.

The dissertation defense will occur after completing the committee's requirements. The candidate should seek regular meetings with the committee, approximately every six months. It is expected that the Ph.D. dissertation will lead to published journal articles. The number of publishable articles will be decided by the candidate and the advisor in consultation with the dissertation committee, but at least one article must be submitted to a peer-reviewed journal for review prior to scheduling a Ph.D. dissertation defense. Doctoral defenses are open to the public. Candidates are required to submit the details (date, time, location) of the meeting, a dissertation abstract, and a listing of all committee members to the administrative staff two-weeks prior to the scheduled defense. Potential outcomes include failure and a pass, and are decided by majority vote of the committee. Failure of the thesis defense requires that a student substantially rework the dissertation and defend the modified dissertation within twelve months. Candidates passing the dissertation defense are typically required to modify the dissertation as directed by the committee. In either case the candidate will be informed of the outcome in a meeting with the advisor and in writing by the Department Chair.

The final dissertation must be submitted in accordance with university regulations. Tufts University has established requirements and deadlines for submission of the final dissertation. See the Arts, Sciences and Engineering Graduate Student Handbook for more information (<http://ase.tufts.edu/gradstudy/GSAShdbk.pdf>). For more information see Appendix A.

6. Certificate Program Requirements

6.1. Water: Systems, Science and Society (WSSS) is a unique MS/MA and PhD certificate program which provides interdisciplinary perspectives and tools to manage water related problems. Tufts schools participating in WSSS include Arts and Sciences, Engineering, Medicine, Veterinary Medicine, the Friedman School of Nutrition and Policy, and the Fletcher School of Law and Diplomacy. CEE Students participating in WSSS must be working towards a graduate degree in either the Environmental Health or Environmental and Water Resources Engineering program. Upon completion of the specific WSSS requirements (see below), students receive a Certificate in Water: Systems, Science, and Society as well as their graduate degree. The WSSS program makes use of electives and co-listed courses to satisfy both the degree program and certificate program requirements. Thus, participation in WSSS should not to add time to the graduate degree.

WSSS students work in one of six interdisciplinary research areas; climate and environmental change, public health, pollution and remediation science, watershed management, food and livelihood security, and national and international security. The WSSS requirements provide students the necessary tools and skills to address the multidimensional problems inherent in water resource issues. Depending upon degree program, WSSS students take courses in three or four core areas and participate in cross-cutting seminars. WSSS students also participate in a Professional Interdisciplinary Experience and skill workshops while completing their research.

Requirements:

A. Courses – MS/MA students are required to take one approved course in each of three of the core areas below. PhD students are required to take one course in each of the four areas. In addition, all first year WSSS students are required to participate in the WSSS Research Practicum, given as a course in the Spring. The four core areas include material the WSSS Program deems necessary for integrated analysis of water issues. Approved courses are listed in the Student Handbook at www.tufts.edu/water.

Water Resources Science and Technology

Biology of Water and Health

Systems Analysis and Economics

Water Policy and Planning

B. Seminar Series – all students are required to participate in interdisciplinary seminars held throughout the academic year.

C. Workshops – Students are required to participate in one year of a workshop series designed to develop skills in leadership, public speaking, teaching, development of research and program proposals, project management and budgeting, and the ethical conduct of research.

D. Interdisciplinary Professional Experience (IPE) – The objective of this activity is for a student to gain some interdisciplinary professional experience in resolving or managing a water resources issue. It is to total 155 hours and can be all at once or spread over period the student is participating in the WSSS program. Typically a student will undertake it during the summer after the first year of graduate school. Examples include an internship with an international nongovernmental organization or government agency, on- or off- campus research experience, and temporary employment in a consulting firm or other organization. IPEs must be approved by the relevant School's WSSS coordinator. All WSSS affiliated faculty member are available to help identify potential IPE opportunities.

E. Thesis – Both MS and Ph.D. theses must be interdisciplinary and have committees with faculty members from at least two WSSS participating schools.

For additional information on the WSSS certificate program go online to: <http://www.tufts.edu/water> or contact: Prof. Paul Kirshen, WSSS co-chair

Department of Civil and Environmental Engineering

617-627-5589

paul.kirshen@tufts.edu

6.2. Epidemiology Certificate program is a graduate-level program offered to individuals interested in advanced training in epidemiology. Students have the opportunity of studying across multiple Tufts campuses. Relevant courses are offered by the Medical School and the School of Nutrition in addition to the School of Engineering. Students can focus on a variety of epidemiologic areas, including the association of various environmental or occupational exposures with chronic diseases, the statistical analysis of epidemiologic data, cancer epidemiology, and the role of nutritional factors in chronic diseases. The certificate program for each student is individualized, so other concentrations are possible. To accommodate working professionals, the Certificate in Epidemiology can be completed using only evening courses. Five courses are required to complete the certificate.

Who Should Apply?

The program is open to individuals with a bachelor's degree. The program is especially appropriate for a wide range of professionals including clinicians (physicians, veterinarians, dentists, dieticians, nurses, social workers, psychologists), hospital and public health agency administrators, human services professionals, lawyers, pharmaceutical and biotechnology personnel, industrial hygienists, and environmental engineers and scientists. Members of boards of health and citizen-activist groups focusing on health-related outcomes who must provide and interpret epidemiologic findings to the public will also find the program valuable.

Designed to focus on an emerging or rapidly evolving field, a certificate is a coherent set of advanced courses that can serve as a credential for professional advancement or as an intermediate step to a related master's degree.

A certificate combines up-to-date theoretical and applied information in a format that allows you to combine quality academic study with your professional responsibilities. Classes are held in the evening to accommodate the working professional. Most certificates can be completed in as little as one year, on a part-time basis.

A Tufts certificate represents approximately one -half of a master's degree program, and is usually more practice-oriented. Because the courses are graduate-level, certificate students may transfer up to four applicable certificate courses to a Tufts degree program at a future date.

For information about the Epidemiology Certificate Program contact:

Mark A. Woodin

617-627-3640

mark.woodin@tufts.edu.

6.3. Environmental Management Certificate program is an advanced certificate offered, on a part-time basis, to qualified students seeking professional training in this critical area where management intersects with environmental technology. A certificate is a nationally-recognized credential designed to train professionals for responsibilities in an emerging or rapidly evolving field. An advanced certificate provides a coherent academic curriculum beyond the bachelor's degree, helping to build a foundation of knowledge that suits individuals' needs and provides a tangible credential.

Certificate students will learn:

- relevant environmental concepts
- current environmental law and regulations
- health and safety issues and risk assessment techniques
- strategic environmental management tools

The certificate builds on the strength of existing Tufts programs. Certificate students are given the flexibility to choose from among courses created exclusively for the certificate, as well as sample Tufts' standard-format graduate course offerings in the Department of Civil and Environmental Engineering and the Department of Urban and Environmental Policy.

This certificate represents approximately one-half of a master's degree program. It is more practice-oriented, geared to people who may already have advanced degrees but may want to shift or enhance their expertise, who can't or don't want to commit to a degree program, or who want to rapidly retrain or refocus their career. In fact, some courses taken as a certificate student can transfer to a Tufts degree program.

For information about the Environmental Management Certificate contact:

Anne Marie Desmarais

617-627-3763

annemarie.desmarais@tufts.edu.

7. Faculty and Staff

Masoud Sanayei, Professor

Department Chair

Anderson 113, masoud.sanayei@tufts.edu

(Ph.D. University of California, Los Angeles)

Professor Sanayei teaches in the areas of mechanics, structural analysis, finite element analysis, and structural dynamics and earthquake engineering. His research activities include bridge health monitoring and damage assessment of structures, floor vibrations testing, and nondestructive laboratory and field-testing.

Linda M. Abriola, Professor

Dean, School of Engineering

Anderson 105, linda.abriola@tufts.edu

(Ph.D., Princeton University)

Professor Abriola specializes in groundwater hydrology. Her primary research area is in the development and verification of models that describe reactive flow and transport in porous media. Recent research work involves the use of models, laboratory experiments, and field tests to explore processes influencing the persistence, distribution, and remediation of liquid chlorinated solvent contaminants in the subsurface and the environmental transport of carbon nanoparticles. Professor Abriola holds an Adjunct faculty appointment in the Department of Chemical and Biological Engineering. Her numerous service activities include membership on the governing Council of the National Academy of Engineering.

Lawrence S. Bacow, Adjunct Professor

President Tufts University

Steven C. Chapra, Professor

Louis Berger Chair in Computing and Engineering

Anderson 223, steven.chapra@tufts.edu

(Ph.D., University of Michigan)

Professor Chapra teaches in the areas of environmental engineering, engineering computing and numerical methods. His research activities focus on water quality modeling and management, environmental physics and chemistry, and advanced decision support systems in environmental engineering. He is an active participant in the Tufts WaterSHED Center.

Lewis Edgers, Professor

Associate Dean for Undergraduate Curriculum Development

Anderson 308D, lewis.edgers@tufts.edu

(Ph.D., Massachusetts Institute of Technology)

Professor Edgers teaches in the areas of solid mechanics and geotechnical engineering. His current research focuses on natural hazards (rainfall induced landslides) and on offshore geotechnical engineering (for wind farms). He is a fellow of the American Society of Civil Engineers, past president of the Boston Society of Civil Engineers, a registered professional engineer, and recipient of the Henry and Madeline Fischer Award for excellence in teaching in the School of Engineering.

Grant Garvin, Adjunct Professor,

Professor, Department of Geology

(Ph.D. University of British Columbia)
Dr. Garvin specializes in groundwater geology and hydrology.

Mark Kachanov, Adjunct Professor

Professor, Department of Mechanical Engineering
(Ph.D. Brown University)
Dr. Kachanov specializes in solid mechanics and applied mathematics.

Shafiqul Islam, Professor

Associate Dean of Engineering for Research

Anderson 311, shafiqul.islam@tufts.edu

(Sc.D., Massachusetts Institute of Technology)

Professor Islam's teaching and research interests are to understand characterize, measure, and model land surface and boundary layer processes with a particular emphasis on scale issues and remote sensing. His research group emphasizes interdisciplinary collaborative partnership to address contemporary problems of environmental hydrology focusing on scarcity and abundance of water.

Richard M. Vogel, Professor

Anderson 308-E, richard.vogel@tufts.edu

(Ph.D., Cornell University)

Professor Vogel teaches in the areas of hydrology, river hydraulics, environmental statistics and water resource systems. His research activities are in the areas of: regional hydrology, watershed modeling, natural hazards, environmental statistics and water resource systems.

Laurie G. Baise, Associate Professor

Anderson 308C, laurie.baise@tufts.edu

(Ph.D., University of California, Berkeley)

Professor Baise teaches in the areas of engineering geology and geotechnical earthquake engineering. Her research activities are in earthquake ground motion modeling, geo-hazard assessment, and geo-statistical evaluation of data.

Wayne A. Chudyk, Associate Professor

Anderson 303, wayne.chudyk@tufts.edu

(Ph.D., University of Illinois at Urbana)

Professor Chudyk teaches in the areas of mechanics and environmental engineering. His research activities are in surface and ground water monitoring using portable, real-time instruments. He is the director of the BSCE program and an active leader in the interdisciplinary environmental studies program.

Luis Dorfmann, Associate Professor

Anderson 308B, luis.dorfmann@tufts.edu

(Ph.D., University of California, Los Angeles)

Professor Dorfmann's interests lie in the areas of structural engineering and applied mechanics. His teaching and research efforts span across the varied areas of engineering materials, solid mechanics and biomechanics. A recently developed interest is the application of coupled nonlinear magnetoelasticity theory in the modeling of magneto-sensitive elastomers and in the mechanics of electroelastic materials. Dr. Dorfmann also holds an Adjunct Associate Professor appointment in the Department of Biomedical Engineering at Tufts University.

John L. Durant, Associate Professor

Anderson 018A, john.durant@tufts.edu

(Ph.D., Massachusetts Institute of Technology)

Professor Durant teaches in the areas of environmental fluid mechanics and chemical fate and transport. His research involves the fate and transport of organic and inorganic pollutants in the aquatic environment with particular emphasis on sediment-water interactions, river restoration and watershed management. He is a member of both the Tufts Watershed Center and the Steering Committee of the Mystic Watershed Collaboration.

Jeffrey Griffiths, Adjunct Professor

Associate Professor, Tufts School of Medicine

David M. Gute, Associate Professor

Anderson 310, david.gute@tufts.edu

(Ph.D, M.P.H. Yale University)

Professor Gute teaches courses in epidemiology, public health and occupational environmental health and safety and occupational environmental health and safety. His research activities are exploring the intersection of pollution prevention and occupational safety and health, assessing the impact of global climate change on human health and in developing effective means of communicating environmental risk to communities throughout New England. Dr. Gute holds faculty appointments in the School of Medicine and the School of Nutrition Science and Policy and coordinates the M.S. program in Environmental Health.

Stephen H. Levine, Associate Professor

Anderson 302, stephen.levine@tufts.edu

(Ph.D., University of Massachusetts, Amherst)

Professor Levine teaches in the areas of operations research and engineering economics. His research activities are in mathematical and computer modeling of environmental and economic systems, and in industrial ecology.

Christopher W. Swan, Associate Professor

Anderson 111, chris.swan@tufts.edu

Faculty Fellow, University College of Citizenship and Public Service

(Sc.D., Massachusetts Institute of Technology)

Professor Swan specializes in the areas of waste reuse, geotechnical, and geoenvironmental engineering. He teaches courses in groundwater hydrology, site remediation, material mechanics, and laboratory (soil) measurement techniques. His most recent research focuses on the beneficial reuse of hazardous or non-hazardous waste materials. He is an active participant in the University College of Citizenship and Public Service which actively promotes education for active citizenship (E4AC) as a component of a student's education.

Babak Moaveni, Assistant Professor

Anderson 206A, babak.moaveni@tufts.edu

(Ph.D., University of California, San Diego)

Dr. Moaveni is interested in structural analysis, statistics and probability, structural dynamics, random vibrations, and parametric identification. His research activities include system and damage identification of civil structures, experimental modal analysis, and uncertainty quantification.

Andrew Ramsburg, Assistant Professor

Anderson 209, andrew.ramsburg@tufts.edu

(Ph.D., Georgia Institute of Technology)

Dr. Ramsburg's research interests are centered on the fate, transport, and remediation of contaminants in the subsurface environment. He is currently working to develop and refine innovative aquifer remediation technologies for the clean-up of sites contaminated with organic solvents, as well as elucidate the impacts of physical-chemical processes on microbial degradation of groundwater contaminants.

Brian Brenner, Professor of the Practice

Anderson 320, brian.brenner@tufts.edu

(M.S., Massachusetts Institute of Technology)

Mr. Brenner, P.E., teaches in the areas of concrete design, bridge analysis and design, and structural analysis/design and mechanics. He comes to Tufts after 20 years of professional practice. He is interested in research in engineering education, bridge design topics, and engineering related to urban design and infrastructure. He is the Editor of the Journal of Leadership in Management and Engineering.

Eric Hines, Professor of the Practice

Anderson 320, emhines@lemessurier.com

(Ph.D., University of California, San Diego, P.E. Massachusetts)

Dr. Hines, P.E., teaches in the areas of steel design, earthquake engineering, and structural systems design. His research activities include the performance assessment of low-ductility structural systems in moderate seismic regions, the inelastic flexure-shear behavior of reinforced concrete members, and the assessment of building systems subject to low amplitude vibrations. Dr. Hines is an Associate at LeMessurier Consultants in Cambridge, where he is responsible for the structural design of building systems.

Paul H. Kirshen, Research Professor

Director, Water: Systems Science and Society Interdisciplinary Graduate Education Program

Anderson 322, paul.kirshen@tufts.edu

(Ph.D., Massachusetts Institute of Technology)

Dr. Kirshen's research activities are in integrated water resources management and policy, decision support systems, and climate change. Projects are being conducted locally, nationally, and internationally, particularly in Africa. He is Director of the Water: Systems, Science, and Society, (WSSS) Program and teaches integrated water resources planning and management. He also is a member of the Mystic Watershed Collaborative.

Lee R. Minardi, Senior Lecturer

Anderson 304, lee.minardi@tufts.edu

(M.S., Tufts University)

Mr. Minardi teaches in the areas of Computer Aided Design and engineering mechanics. His research interests include geometric modeling of mechanical products and infrastructure systems, visualization of engineering principles and data, and the use of technology for enhancing the learning process. Sample research projects have included: the posting of real-time water quality data for the Mystic River Watershed on the internet, the visualization of PCBs in river sediment, web-based access to subsurface data, and the use of VBA for teaching CAD math.

Mark Woodin, Senior Lecturer, Research Assistant Professor

Anderson 113-C, mark.woodin@tufts.edu

(Sc.D., Harvard University)

Dr. Woodin teaches in the areas of epidemiology, environmental health, and biostatistics. His research activities currently include occupational epidemiology, the epidemiology of metal exposure, and community health research. He is Director of the Epidemiology Certificate Program and is active in the Technical Outreach and Service to Communities Program.

Anne Marie C. Desmarais, Lecturer

Anderson 321, annemarie.desmarais@tufts.edu

(M.S.P.H., University of Massachusetts)

Ms. Desmarais teaches graduate courses in risk and exposure assessment and undergraduate courses in environmental technology and hazardous materials management. Her interests are in developing quantitative methods to evaluate exposure to hazardous materials in environmental media.

Linfield C. Brown, Emeritus Faculty

Anderson 320, linfield.brown@tufts.edu

(Ph.D., University of Wisconsin-Madison)

Professor Brown teaches in the areas of environmental engineering, unit operations and processes, and engineering statistics. His research is in water quality modeling and the applications of statistics to a variety of environmental engineering problems. He is co-author of the book *Statistics for Environmental Engineers*, and recipient of the Lillian Liebner Award for excellence in teaching and advising.

Part-Time Lecturers:

Lecturer Po-Shang Chen, *Structural Engineering*

Lecturer Larry Cohen, *Hazardous Waste Treatment*

Lecturer David Hatem, *Legal Issues*

Lecturer Amy Hirshfeld, *Technical Writing*

Lecturer Masoud Olia, *Applied Mechanics*

Lecturer Michael Paster, *Geotechnical Engineering*

Lecturer David Travis, *Engineering Management*

Staff:

Judith Farrington, *Department Administrator*, Anderson 113, judith.farrington@tufts.edu
617-627-2719

Laura Sacco, *Graduate Coordinator*, Anderson 113, laura.sacco@tufts.edu
617-627-3211

Grace Clemence, *Undergraduate Coordinator*, Anderson 113, grace.clemence@tufts.edu
617-627-3211

Stephen Fratto, *Engineering Lab Coordinator*, Anderson 010, stephen.fratto@tufts.edu
617-627-3661

8. CEE Courses for Graduate Students

CEE-103 Water Quality Modeling. The application of mathematical models and statistics to the study of water quality in rivers, lakes and estuaries. Topics include transport, temperature, dissolved oxygen, eutrophication, chemical equilibrium, pathogen, and toxics modeling. Manipulation of field data, model calibration and corroboration, parameter estimation, analytical and numerical solution. Prerequisites: Math 38 (Differential Equations), introduction to environmental engineering (CE-11 or equivalent). Spring, *Chapra*.

CEE-105 Finite Element Analysis. Finite element analysis of problems important in civil infrastructure engineering. Overview of direct stiffness method. Discretization of continuum to finite elements for approximate solution of complex engineering problems. Development of governing equations, stiffness, and load matrices for deformation and stress analysis. Work and energy theorems. Hands-on experience with computers, CAD and practical applications to problems in structural and geotechnical engineering. Prerequisite: ES-9. Spring. *Sanayei*.

CEE-106 Structural Dynamics & Earthquake Eng. Fundamentals of vibration theory with applications important in civil infrastructure engineering. Free, forced, and transient vibration of one and two degrees of freedom systems including damping and nonlinear behavior. Base excitation and seismic instrumentation Duhamel's integral and time step integration. Multi-degree of freedom systems, nodal analysis and seismic response spectra. Introduction to earthquake design to geotechnical and structural engineering. Prerequisite: ES-6 or consent. Spring. *Sanayei*.

CEE-112 Hydrology and Water Resource Engineering. An Introduction to the science of hydrology and to the design of water resource systems. Basic hydrologic processes such as precipitation, infiltration, groundwater flow, evaporation, and streamflow are discussed. Applications of hydrology to water supply and flood control are emphasized. Students develop their own hydrologic models using computer software. Prerequisite: CEE-12 or consent. Fall. *Vogel*.

CEE-113 Groundwater Hydrology. Fundamental engineering concepts in groundwater hydrology as related to the occurrence, movement, quality, and modeling of groundwater resources. Topics include hydraulic conductivity, well hydraulics, numerical modeling, field exploration techniques, well installation and construction considerations, and contaminant transport. Prerequisite: senior standing or consent. Fall. *Members of the Department*.

CEE-122 Advanced Strength of Materials. (Co-listed Mechanical Engineering-ME 122). An introduction to the theory of elasticity with emphasis on plane elasticity. Theories of stress, strain and equilibrium. The Airy stress function with applications to the bending of beams and stress concentrations. Saint-Venant torsion. Prerequisites: ES-9, Mathematics 151 or ME-150. *Kachanov*.

CEE-123 Advanced Structural Systems Analysis. The application of mechanics to the analysis of indeterminate structural forms important to civil and aeronautical engineering, with emphasis on modern structural types. The analysis of fundamental structural forms, including curved beams, arches, rings, thin-walled cell-type structures, and members with variable inertia, for stress and deflection by the classical methods. Influence lines for indeterminate structures. Introduction to matrix analysis and vibration of structures. Prerequisite: CEE-22. Fall. *Sanayei*.

CEE-124 Advanced Steel Design. The course focuses on the detailed design of structural steel systems based on a fundamental understanding of these systems' behavior and failure modes. Special emphasis is placed on conceptual design, communication of design concepts, the development of structural details, and the interplay between efficiency, economy and elegance. Student performance is assessed in the context of a design studio through a series of projects that are drawn from the instructor's own work. Prerequisites: Permission of instructor *Hines*

CEE-125 Advanced Reinforced Concrete Design. Further study of concrete design with emphasis on columns with biaxial bending, concrete torsion, strut and tie models, flat slab theory and design, walls, footings, and the analysis and design of prestressed concrete structural members. Prerequisite: CEE-25. Spring. *Brenner*

CEE-126 Structural Stability. Elastic buckling of columns, including the effects of initial crookedness and eccentricity. Large deflections of the Euler column. Tangent modulus and double modulus theory. Beam columns and the stability of frameworks and trusses. Torsional buckling of columns and lateral buckling of beams. Plate buckling with applications to flange buckling and web crippling of plate girders. Prerequisite: CEE-22. *Chen*.

CEE-128 Structural Mechanics. (Cross-listed ME-128). The objective of this course is to cover the fundamentals of structural mechanics, including experimental, modeling and computational perspectives. The course is structured as follows: (a) Overview of vector and tensor manipulations; (b) Geometry of deformation; (c) Transmission of force; (d) Elastic constitutive equations; (e) Principle of virtual work and Ritz approximation; (f) Linear theory of beams and plates; (g) Energy principle and stability. Fall: *Dorfmann*

CEE-129 Bridge Design and Rehabilitation. A practical introduction to bridge engineering, exploring the design, behavior, maintenance and rehabilitation of bridges. Bridge systems, loadings, superstructures, substructures, details, and inspections will be discussed. The theory behind development of certain provisions in AASHTO code will be reviewed, with the purpose of developing an understanding of the code and its related commentary, and the objective of preparing students to use the criteria not as a "black box". Approximate analysis methods will be discussed. Design of elements including steel and pre-stressed concrete beams, abutments, piers, joints, and bearings using AASHTO code (LRFD) will be covered. Prerequisites: CEE-24 and CEE-25 or consent. Spring. *Brenner*.

CEE-131 River Hydraulics and Restoration. The physical and mathematical basis for steady and unsteady flow processes in hydraulic engineering, with emphasis on fluvial systems. Numerical procedures for gradually varied steady flow and rapidly varied unsteady flow will be covered with applications to floodplain delineations, flood routing, dam safety, and river restoration. Other applications may include the design of hydraulic structures such as culverts, stilling basins, spillways, levees, weirs, fish ladders, and retention/detention ponds. With laboratory. Prerequisite: CEE- 12. Alternate Fall, *Vogel*.

CEE-132 Environmental Engineering Processes. Study of the chemical, physical, and biological basis for the unit processes commonly used in environmental engineering. Processes representing applications in all environmental media are examined. Emphasis is on rational design of unit processes, with attention to fundamental principles. With Laboratory. Prerequisite: CEE- 32 or equivalent. Fall., *Chudyk*.

CEE-133 Water and Wastewater Plant Design. Design of facilities for municipal drinking water and wastewater treatment. Synthesis of unit processes and operations into integrated treatment plant. Emphasis on conventional treatment processes. Additional topics include liquid and solids streams, hydraulics, chemical feed and control systems, costs, and performance requirements. Design projects and field trips. Prerequisite: CEE-12 and CEE-32. Spring. *Chudyk*.

CEE-134 Water and Wastewater Chemistry. The application of basic fundamentals of analytical, physical, and organic chemistry to the quantitative analyses necessary for the research, design, and operation of sanitary engineering processes. With laboratory. Prerequisite: CEE-32. Fall. *Chudyk*.

CEE-136 Air Pollution. Air Pollution predates recorded history, and (through breathing) serves as a widely accessible means of exposure to contaminants. This course explores the causes, effects, and mitigation of air pollution. The web of topics covered includes identification and estimation of sources, health and environmental effects, environmental law and regulations, modeling and evaluation techniques, and control strategies and technologies. Fall. *Frecker, Kennedy*.

CEE-137 Public Health. An introduction to the public health approach is provided. The epidemiological model of the disease process is used to study a variety of infectious and noninfectious diseases. The wide variety of nonmedical approaches to disease control is emphasized. The public health aspects of vital statistics, evaluation, and administrative decision making are introduced and applied to current problems in public health. Prerequisite: consent. Fall. *Gute*.

CEE-138 Hazardous Waste Treatment Technology. Hazardous waste treatment options based on physical, chemical, biological, and thermal processing technologies. Brief review of definitions and appropriate hazardous waste legislation. Introduction to pollution prevention. Traditional end-of-pipe treatment technologies. Applications to include solvent recovery, chemical fixation, land disposal, biodegradation, and special wastes. Incineration and associated environmental discharges constitute a major portion of course. Emerging technologies and evaluation of technical/economic process viability. Prerequisite: Senior standing or consent. *Cohen*.

CEE-139 Bioremediation: Natural and Enhanced. Biodegradation of organic contaminants is evaluated in natural settings and in treatment processes. Aerobic and anaerobic pathways, their prediction and control are examined. Water, soil, and vapor phase transformations are evaluated. Subject areas included kinetics, equilibria, sorption, gas transfer, and transformation products. Process design for treatment plants and *in-situ* applications applied to case studies. Corequisite: CEE-132. Spring, *Chudyk*.

CEE-142 Advanced Soil Mechanics:

Soil composition, index properties, classification. Mohr circles and stress paths. Consolidation behavior; soil properties related to compressibility; consolidation theory including radial and 3-D solutions; secondary compression. Shear strength characteristics of soil; effects of soil composition, stress history, stress path, drainage conditions and rate of loading on stress-strain-strength response of soil. Prerequisite: CEE-42. *Edgers*

CEE-143 Site Remediation. Conventional and innovative remediation technologies are examined under the remedial investigation/feasibility study (RI/FS) process. Knowledge of fundamental processes governing remedy implementation is integrated with an understanding of site characterization and applicable regulations, to enable design of site-specific treatment systems for clean-up of the contaminated subsurface environment. Prerequisite: Mathematics 38, or consent of instructor. Spring, *Ramsburg*

CEE-145 Computer Methods in Geotechnical Engineering. Computer methods for processing subsurface information and for analyzing geotechnical/geoenvironmental engineering problems. Applications to be selected from settlement, deformation, bearing capacity, slope stability, pile driving, Darcy flow, and soil amplification analyses. Finite element and finite difference applications. Prerequisites: CEE-42. *Edgers*.

CEE-146 Foundation Engineering. Geotechnical explorations. Bearing capacity and settlement analyses for shallow (footing and raft) and deep (pile) foundations. Design of footings, rafts, piles, and piers subjected to axial and lateral loads; building code requirements for design; and evaluation and selection of foundation types and alternatives. Case studies. Prerequisite: CEE-42. Fall. *Edgers*.

CEE-147 Soil Dynamics and Earthquake Engineering. Review of elementary vibration and wave propagation theory. Occurrence and quantification of seismic events. deterministic and probability seismic hazard analysis. Dynamic behavior of soils including soil amplification concepts and liquefaction. Prerequisite: ES-6, CEE-42. *Baise*.

CEE-149 Earth Support Systems. Examination of earth pressure theories and design problems related to earth-retaining structures and tunnels. Analysis and design of braced and unbraced excavations; code requirements; strut-water systems; tie backs; ground movement control; reinforced earth and slurry wall methods. Slope stability analysis related to excavations and retaining structures. Prerequisite: CEE-42. Spring. *Paster*.

CEE-152 Engineering Systems: Stochastic Models. (Cross-listed as Engineering Psychology 152 and Engineering Sci. 152.) An introduction to network models in the analysis and design of engineering, economic, environmental, and social systems with an emphasis on systems exhibiting stochastic behavior. Topics include computer simulation, network models, Markov chains, queuing theory, reliability analysis, genetic algorithms, simulated annealing, and game theory. Prerequisites: Math 38 or consent. Spring. *Levine*.

CEE-154 Principles of Epidemiology. Epidemiology is the science that examines health and disease processes in human populations. Topics include epidemiologic rates and measures, study design, sources of inaccuracy and bias in experimental and observational studies, the methodology of data collection, screening, and an introduction to the statistical evaluation of epidemiological data. Prerequisite: consent. Fall. *Woodin*. Note: Students cannot take CEE-154 after completing CEE-54 without written permission from the instructor justifying the taking of both courses *Members of the Department*.

CEE-158 Occupational and Environmental Health. An examination of current topics in the area of occupational and environmental health, with particular emphasis on the types of materials that produce human health effects. Both clinical and epidemiologic data will be used to assess the public health importance of environmental pollutants and to evaluate the effectiveness of control strategies. Prerequisite: senior standing or consent. Spring. *Gute*.

CEE-161 Internship in Epidemiology and Biostatistics. Monitored field experience in a cooperating agency. Students experience various professional settings related to career possibilities. Situations selected by past interns include problems of biological measurement, hazardous

waste evaluation, and topics in engineering health and safety. Placement can be chosen in an appropriate setting. Prerequisite: CEE-154 and CEE-160. *Gute*.

CEE-164 Epidemiologic Methods. (Continuation of CEE-154.) An intensive introduction to the evaluation of current research controversies in epidemiology. Extensive use will be made of class discussion of epidemiologic articles from both the scientific and popular press. A major focus of the course will be on determining the validity of epidemiologic findings by evaluating how well researchers handled bias, confounding, statistical analysis, and other methodological issues. Prerequisite: CEE-154, MPH-201, or CEE-54 (with consent of instructor). Spring. *Woodin*

CEE-167 Environmental Toxicology. This course is designed to present the basic scientific principles of toxicology and the relationship of toxicology to health-based risk assessment and hazardous materials management. The toxic effects of hazardous substances on specific organ systems are described as well as the mechanisms of action of some frequently encountered environmental contaminants. Specialized topics related to the field of toxicology are also discussed including animal to human extrapolation of data, mutagenicity/carcinogenicity and teratogenesis. Prerequisite: senior standing or consent. *Members of the Department*.

CEE-168 Exposure Assessment. Methods for evaluating human exposure to hazardous substances present in the environment or the work place. Estimated total human exposure to chemicals from all sources, including air, water, food, and soil as well as exposures to non-human receptors are discussed. Difficulty of measuring damage to the environment is explored. Prerequisite: CEE173. Spring. *Desmarais*.

CEE-172 Fate and Transport of Environmental Contaminants. A study of the movement and distribution of contaminants in the air, water, and soil environments. An in-depth study of fate and transport mechanisms. Transport modeling, measurement and monitoring, as well as analytical methodologies for measuring environmental contaminants and quality assurance protocols. Prerequisite: CEE-32. Spring. *Chudyk, Durant*.

CEE-173 Health Effects and Risk Assessment. A study of chronic and acute human health effects of exposure to hazardous materials. Principles of toxicology and pharmacokinetics of toxic substances. Standards for environmental quality, risk assessment methodologies and risk communication strategies. Prerequisite: senior standing and consent. Fall. *Desmarais*.

CEE-175 Hazardous Materials Safety. An examination of strategies for controlling occupational exposures and reducing risk from hazardous materials in the work place. Chronic health hazards to workers and the public, acute risks to both workers and surrounding community, and the legal aspects associated with these risks are explored. Safety and health programs are considered. Prerequisite: senior standing or consent. *Desmarais*.

CEE-185 Legal Issues in Engineering Practice This course examines the legal principles applicable to engineering design, construction, and manufacturing. Topics covered include: introduction to the legal system; sources of law; contract law principles; professional liability risks; risk management practices; contract administration; differing site conditions claims; professional registration and ethical issues. Spring. *Hatem*.

CEE-188 Engineering Design with CAD. The application of CAD technology to engineering design and an overview of the basic concepts integral to computer-aided design (CAD) systems. Several engineering design projects are utilized to reinforce the theory and practical operation of modern CAD systems. Topics include geometric modeling of complex surfaces, solid modeling, assemblies, and introduction to finite element modeling and analysis (FEM/FEA), variational and parametric modeling, graphics programming of CAD systems and visualization with CAD. Prerequisite: consent. Spring, *Minardi*.

CEE-193, 194 Special Topics. Guided independent study of an approved topic at the graduate level. Prerequisite: consent. Credit as arranged. *Members of the Department*.

CEE-193A Engineering Geology. The study of geologic effects on engineering projects and decisions. Engineering properties of igneous, sedimentary, and metamorphic rocks. The engineering issues of sedimentary environments. Rock and soil slope stability, and earthquake hazards. The student will learn to recognize environments where geologic hazards may exist and to perform the appropriate investigations and analysis to properly assess the hazard through case studies. Prerequisite: Geo-1 or Geo-2. Fall. *Baise*.

CEE-193G Introduction to Geographic Information Systems. Geographic Information Systems (GIS) are computer-based systems used to enter, store, transform, map, analyze and interpret spatial data. In this introductory course we will study how GIS systems work, how data is generated, and how to use different software tools to map and analyze GIS data. Emphasis will be placed on the basic elements of cartography and GIS (lecture) and hands-on applications (labs). Applications will be made to a broad range of environmental and engineering problems. Prerequisite: None. Spring. *Durant*.

CEE-120/FAH-290: The Art of Building: The seminar addresses the problem of creating a built environment consistent with modern life. It explores connections between structural form and architectural discourse during late 19th and early 20th centuries, focusing on the work of key designers and writers who shaped the discussion of this program. Students are required to critique developments in modern structure and modern architecture according to their artistic significance, their ability to carry loads efficiently and the social ramifications of their construction. Based on the discussions of historic structures, the seminar develops ideas about the present relationship between structure and architecture. **Prerequisite:** Permission of instructor. *Hines*

CEE-193X Site Investigation Techniques. All phases of site investigation and hazard assessment require careful planning and assessment of available tools. Site history and aims of use will dictate monitoring of air, soil, surface water, and groundwater. Monitoring technology play a vital role in gathering field data. In this course participants will discuss site investigation, starting with an "unknown" piece of ground. Approaches to sampling strategies, instrumentation, sensors, and other hardware, software, and commonly used protocols will be examined. Instrumentation technology will be evaluated from theoretical and applied perspectives. Practicing professionals will demonstrate equipment used in the field. Fall. *Chudyk, Desmarais*.

CEE-194L Introduction to Industrial Ecology. An introduction to some basic concepts and tools of industrial ecology. Similarities, differences, and interactions of industrial systems and ecological systems. Topics include Life-Cycle Assessment (LCA), Material Flow Analysis (MFA), Economic Input-Output (EIO) models, industrial symbiosis, industrial ecosystems, and Earth Systems Engineering. Prerequisite: Math 12, Junior standing or consent. Spring. *Levine*.

CE-194N, ME-149C - Nonlinear Finite Elements for Solids and Structures: The objective of this course is to introduce basic concepts necessary to appreciate the correspondence between nonlinear solid mechanics, nonlinear constitutive models and variational principles as essential prerequisites for nonlinear finite element formulations. The course is structured as follows: (a) Overview of properties of vector and tensor manipulations; (b) Formulations for the description of motions and finite deformations; (c) Cauchy stress theorem, different stress measures such as nominal stress, Cauchy stress and Piola-Kirchhoff stress; (d) Equilibrium equations in Lagrangian and Eulerian descriptions; (e) Construction of nonlinear constitutive equations; (f) Discussion of recently published constitutive models for biological and engineered soft materials; (g) Participants will select a constitutive formulations to fit the nonlinear response of soft materials. This can be done using MatLab or a user subroutine in Abaqus. Spring. *Dorfmann*.

CEE-201 Land Use Planning and Policy. (Cross-listed as UEP 201.) An overview of land use planning methods, growth dynamics, and land development controls. Comparison of different approaches to land use planning and decision making. Impact of recent environmental legislation of land use. Techniques of mapping, site analysis, subdivision regulation, development controls, and fiscal incentives. Prerequisite UEP 205 or consent. Spring. *Witten*

CEE-202 Environmental Statistics. Methods for analyzing environmental data which is often censored, skewed, and correlated in space and time. Topics included exploratory data analysis, nonparametric methods, hypothesis testing, multivariate statistics, frequency analysis, uncertainty analysis, experimental design, and model building. Prerequisite: ES 56 or Mathematics 161-162. Alternate Fall, *Vogel*.

CEE-207 Environmental Law. (Cross-listed as UEP-207.) Evolving principles of environmental law in courts, legislatures, agencies, and local settings. Legal background on land use, health regulation, pollution, waste, toxic chemicals, and environmental impact statements. Emphasis on individual and institutional rights, responsibilities, and accountability under law. Fall. *Russell*.

CEE-212 Chemical Principles in Environmental and Water Resources Engineering. This course focuses on the basic principles of chemistry as they apply to problems in environmental and water resources engineering. Emphasis is placed on developing an understanding of the thermodynamic and chemical equilibrium principles that underlie important processes in natural water and engineered aquatic systems. Because this course is taught in an engineering department, significant emphasis is placed on quantitative problem solving. The goal of the course is to educate students to be able to solve a wide range of water chemistry problems relevant to environmental and water resources engineering. Prerequisites: undergraduate chemistry. Fall. *Chudyk*.

CEE-213 Transport Principles in Environmental and Water Resources Engineering. An examination of transport phenomena in the natural or engineered environment. Topics include: momentum transport, energy transport, mass transport, interphase mass transfer, and environmental applications of ideal and non-ideal reactor models. Students will enhance their ability to apply a first principles approach for analysis of complex environmental systems. Prerequisites: Equivalent of Mathematics 38 and Engineering Science 8. Fall. *Ramsburg*.

CEE-214 Environmental and Water Resources Systems Engineering. Mathematical models of water resource systems are presented in combination with optimization procedures and decision theory, to generate an integrated approach to the planning, design and management of complex water resource systems. Water resource systems applications are formulated as decision problems where an optimal solution is sought yet cost, safety, sustainability and technology, appear as competing constraints. Applications include regional water quality management, siting treatment plants, reservoir system operations and design, irrigation flood control, river basin planning and others. Spring. *Vogel*.

CEE-221 Introduction to Solid Mechanics. (Cross-listed as Mechanical Engineering 221.) A study of the mechanics of deformable bodies based on equilibrium, geometry of strain, and properties of materials. Relations among stresses, strains, and displacements are studied in detail. Introduction to the theory of elasticity, plasticity, visco-elasticity, and creep. *Kachanov*.

CEE-222 Applied Solid Mechanics. (Cross-listed as Mechanical Engineering 222.) Applications of the theory of elasticity and plasticity to problems of engineering interest. Spring 1995 and alternate years. *Greif*.

CEE-223 Analysis and Design of Plates. The analysis and design of plates and shells with particular emphasis on structures and structural elements of civil engineering interest. Applications to the design of bridge decks and building floors in reinforced concrete, structural plate components in metal tanks, pressure vessels, shell roofs, and hipped-plate construction. Prerequisite: CEE-22. *Members of the Department*.

CEE-225 Advanced Structural Dynamics. (Cross-listed as ME-225). Study of free and forced vibration of continuous structures such as plates and shells. Laplace transform and Fourier series, Rayleigh-Ritz and Galerkin methods. The use of discrete technique, such as finite-difference and finite-element methods to solve practical problems in structural dynamics. *Greif, Sanayei*

CEE-230 Reactive Transport in Porous Media A rigorous exploration of the fundamental processes governing component transport in porous media. Topics include: volume averaging, dispersion, reactive transport, non-linear and non-equilibrium sorption, anomalous transport, mass transfer, multiphase flow and transport. Learners will gain the theoretical foundation on which to base critical assessments of component transport in complex porous media. *Prerequisites:* CEE 213 or consent of instructor Spring (alternating years). *Ramsburg*

CEE-240 Principles of Wastewater Treatment. A study of the underlying principles important in the design of aerobic biological treatment systems. Subject areas include chemical and biological kinetics, gas transfer, reactor design, and computer modeling techniques. Utilization of rational design strategies is stressed. Prerequisite: CEE-133. *Brown, Chudyk*.

CEE-241 Biology of Water and Health. This course explores the influence of waterborne pathogens on human and environmental health. The course allows participants to become familiar with different disciplinary approaches to addressing the assessment and control of environmental and health effects of waterborne contaminants. Gute, Griffiths.

CEE-244 Laboratory and In-Situ Measurement of Soil Properties. In-depth study of various laboratory and in-situ tests used to measure the shear strength, compressibility, and permeability of soils. Laboratory work includes index, consolidation, and triaxial tests. Field tests discussed

include SPT, cone, vane, pressure meter, and dilatometer. Discussion of methods used to process laboratory and field data. Report writing and hands-on laboratory testing. Prerequisite: CEE-42. *Swan*.

CEE-264 Hazardous Materials Management and Policy. (Cross-listed as UEP-264.) The policy making process with respect to hazardous materials from the government, industry, and citizen perspectives. Special emphasis on understanding the relationship between technical, political, and socio-economic factors. Covers facility siting, risk communication, radon, Superfund, and international policies. Spring. *CEE/UEP Faculty*.

CEE-265 Corporate Management of Environmental Issues. (Cross-listed as UEP-265.) Explores companies' responses to pressure from stockholders, regulatory agencies, community and nongovernmental organizations to exercise greater responsibility toward the environment. Topics include strategy, staffing and organization, decision making, codes of conduct, resources, program development, product responsibility, pollution prevention, trade association, and foreign operations. Fall. *Rappaport*.

CEE-267 Methods in Environmental Impact Assessment. (Cross-listed as UEP-267.) Concepts, legal framework, public policies, approaches, and methodologies utilized in determining environmental impacts of proposed public, semipublic, and private actions. Analytic methods for determining environmental impacts and for guiding environmental regulation. Nature of impact examined from the viewpoint of economics, equity, and the environment. Spring. *CEE/UEP Faculty*.

CEE-292R Research Methods for Environmental Health Scientists. This course focuses on how to approach questions in the broad field of environmental health. Topics covered during the first half of the course will include the proper format of research hypotheses, scientific writing style, how to utilize library resources, important statistical principles, and presentation by faculty on their study of various research problems. Later in the course, student Master's thesis research proposals will be discussed, with all members of the class participating in the analysis of each other's ideas. The major course requirement is a completed Master's thesis proposal that the student can refine and implement after the end of the class. This course is required of all Environmental Health Master's students entering their second semester. A limited number of other graduate students may enroll with permission of the instructor and written consent from their advisor. Spring. *Gute, Desmarais, Woodin*.

CEE 293A Environmental Signal Processing This course will focus on understanding and modeling uncertainty and heterogeneity in hydrologic and environmental processes. It will examine probabilistic methods to describe and analyze heterogeneity in temporal and spatial processes. We will explore how the methodologies developed for time series modeling (e.g., Kalman Filter) can be made equivalent to tools used to describe spatial heterogeneity (e.g., Kriging). Here is a list of the major topics we will cover: (a) Generalized Univariate Time Series Analysis: Model identification, parameter estimation, validation, and forecasting; (b) Estimation of Static Linear Systems: Kriging of stationary and nonstationary random processes; and (c) Estimation of Dynamic Processes: Discrete State-Space Model and Kalman Filter. Fall (every other year). *Islam*

CEE 293B – Water: Constraints, Conflicts, and Cooperation at Boundaries This course will explicitly recognize that triple constraints (quantity, quality, and ecological integrity) on water lead to conflicts. Effects of these constraints are often exacerbated at political, physical, and economic boundaries. Triple constraints further lead to conflicts because change, variability, and uncertainty result in evolving contexts and ambiguities. To explore these intricate linkages among interfaces and their multifaceted dimensions, we will use water conflicts in American West and South Asia as our natural laboratories and classrooms. Here is a list of the major topics we will cover: (a) Concepts, methodology, and use of boundary objects to develop shared understanding of multiple constraints and conflicts; (b) Issues of thresholds, complementarities, and tradeoffs among salience, credibility, and legitimacy when crossing boundaries; (c) Relationships and transferability of knowledge and information across boundaries and scales; and (d) Watersheds and problemsheds: Redefining conflicts and constraints for cooperation. Fall (every other year). *Islam*

CEE-294K Integrated Water Resources Management Explores the major issues in integrated socio-economic and biophysical assessment of water resources and analysis methods. The scale includes both river basin and national assessments in both developed and developing countries. Topics include basic hydrologic principles, water uses, water stresses, socio-economic impacts, institutions, management strategies, and national and river basin assessment methodologies. Fall. *Kirshen*.

CEE-294R Transport in Porous Media. A rigorous exploration of the fundamental processes by which components are transported in porous media. Learners will develop the foundation necessary for critical assessment of component transport when designing/conducting experiments in complex porous media systems; working with commercial models to predict component transport; and/or implementing groundwater treatment technologies. Spring. *Ramsburg*

CEE-0294 W Water: Systems, Science, and Society (WSSS) Research Practicum. Students review the process of multidisciplinary research design and then carry out a team research project related to Integrated Water Resources Management. This course is only open to students in the Tufts WSSS Program and also provides a common experience as a bridge to getting to know each other. It is taught in cooperation with UEP Field Projects: Planning & Practice – UEP-255. Spring. *Kirshen*

CEE-293, CEE-294 Special Topics. Guided individual study of an approved topic. Credit as arranged. *CEE Faculty*.

CEE-295, CEE-296 Master's Thesis. Guided research on a topic that has been approved as a suitable subject for a master's thesis. Credit as arranged. *CEE Faculty*.

CEE-297, CEE-298 Doctoral Thesis. Guided research on a topic suitable for a doctoral dissertation. Credit as arranged. *CEE Faculty*.

CEE-299 Master of Engineering Project. A project under the guidance of a faculty advisor which addresses a substantial engineering problem, for example, in engineering design, construction, management, operations and/or planning. Students who are practicing engineers are encouraged to consider projects relevant to their own work. A written report and an oral presentation are required. One course unit. *CEE Faculty*.

401PT Master's Continuation, Part-time.

402FT Master's Continuation, Full-time.

501PT Doctoral Continuation, Part-time.

502FT Doctoral Continuation, Full-time.

Tufts University

Tufts University is committed to ensuring that all its graduates are able to evaluate and respond to the impact of technology and the need for value-based decision making. As a result, the department offers diverse options for academic degrees in the areas of environment and infrastructure, as well as options for specialized training, non-degree course work, and professional development. Tufts is committed to engineering research, technology transfer, and policy development on a local, national, and international scale.

On the boundary of Medford and Somerville, Massachusetts, Tufts sits on a hill overlooking Boston, five miles northwest of the city. The campus is a tranquil New England setting with easy access by subway (Davis Square Station on the Red Line) and buses to the cultural, social, and entertainment resources of Boston and Cambridge.

Of the 9,000 students on the Medford/Somerville campus, approximately 4,900 are undergraduates and 4,100 are graduate students. Most of these students study under the largest division of the university, the School of Arts and Sciences. The division comprises the College of Liberal Arts and Jackson College, Graduate and Professional Studies, and the Summer School. The faculty is committed to scholarship of the highest order and teaching of exacting quality, all in a friendly, open atmosphere.

APPENDIX A
Department of Civil and Environmental Engineering
Guide to Doctoral Degree Requirements

Time Frame	Action	Guidelines
1. Start of PhD	Student and advisor are matched following an interview (can be done by telephone) and a careful scrutiny of interests and funding.	The department is responsible for the students' welfare and the quality of the PhD experience. Normally a student should not be admitted without support.
2. Within 12 months of starting the PhD (usually it will be at the beginning of the Fall semester following the start of the PhD program) Qualifying exam must be taken.	A qualifying exam will be offered at the beginning of the Fall Semester, administered by a Qualifying Exam Committee that will be appointed by the program. Students may petition to re-take the exam once.	Qualifying exam will include written and oral components. The student becomes a candidate after successfully completing the PhD Qualifying examination.
3. The dissertation committee should be formed within 12 months of starting the PhD.	The dissertation committee must comprise at least 4 members, half of which are to be CEE faculty. At least one member must be from outside the Department. It is also required that the majority of the committee members be Graduate faculty (*).	Committee should include one Graduate faculty in the specialty area of study. <u>An individualized curriculum plan will be discussed and approved by the committee.</u> At a minimum, 7 credits beyond MS are required.
4. A dissertation proposal should be prepared and defended <i>at least 12 months before the Final Dissertation Defense.</i>	The proposal should be prepared in consultation with the committee. The PhD proposal should be of a quality suitable for a competitive funding agency. It is very desirable to actually submit this proposal to a national funding agency.	Successful completion of the dissertation proposal defense is a significant milestone towards completing the PhD degree.
5. Final defense will take place after completing the committee's requirements.	The advisor should seek regular meetings with the committee, approximately every six months.	It is expected that the PhD dissertation will lead to published journal articles. Number of publishable articles will be decided by the candidate and the advisor in consultation with the dissertation committee but at least one article must be submitted to a peer-reviewed journal for review prior to scheduling a PhD dissertation defense.

Doctoral Degree Checklist

Last name	First name	Middle initial
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Semester & Year of Doctoral Program Matriculation	Advisor
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Key Milestones (indicate date of completion)

1. _____ Passed Qualifying Exam
2. _____ Doctoral Committee Formed (indicate members and depts. below)

3. _____ Curriculum Approved by Doctoral Committee (7-15 credits, indicate courses)

4. _____ Passed Proposal Defense (indicate working title of dissertation below)

5. _____ Course Work Complete

6. _____ First Manuscript from Doctoral Research Submitted to Peer-Reviewed Journal (indicate manuscript title and journal to which submitted)

7. _____ Passed Doctoral Defense

8. _____ Thesis Submitted Consistent with University Regulations

APPENDIX B

Department of Civil and Environmental Engineering

Guidelines for Teaching and Research Assistants

A number of graduate students receive financial support through assistantships. Unlike fellowships and grants, Teaching Assistantships (TA's) and Research Assistantships (RA's) are jobs. Working as a TA or RA can be rewarding and beneficial experience. These positions should be viewed by students and faculty as important opportunities to further one's career in engineering. While the job functions between TA's and RA's differ, there are some important guidelines which are applicable to both roles. These are outlined below.

Guidelines Which Apply to both TA's and RA's:

- All assistantships (both TA's and RA's) carry a 20 hr/wk commitment. This leaves 20+ hours a week for graduate students to work on their course work and thesis research. Thesis research may be distinct from research conducted as an RA.
- Graduate students and faculty supervisors should establish specific expectations at the beginning of each semester. Doing so will ensure that all parties are cognizant of the specific responsibilities and aware of any major deadlines associated with the particular assistantship.
- Provide regular updates on your progress to the faculty supervisor. Most professors are very busy. If regular meetings are not scheduled by the supervisor, you should take the initiative to schedule them.
- Do not leave on vacation or during semester breaks without permission from your supervisor. The responsibilities of graduate assistantships do not end with the final exam of each semester. Often, as in the winter holiday break, it is expected that graduate assistants work on their assignments (when the University is open) unless previous arrangements with your supervisor have been made.
- Funded graduate students receive priority for student offices. Make good use of this space!
- Telephones are for business related calls only

Guidelines Which Apply to TA's:

- Each TA will have at most two advisors: (1) advisor for TA position termed the teaching advisor (TAD) and (2) research advisor (RAD). Research advisor will act as academic advisor and chair of thesis committee.
- The primary function of a TA is to provide support and assistance to their TAD. Their duties may include: attending course lectures and/or laboratories, assisting instructor in preparation of course materials or laboratory experiments, providing instruction for course recitations and/or laboratories, performing trial runs of lab experiments to ensure quality control, grading course assignments, holding office hours for students, ordering, tracking, and cataloging materials and supplies used and needed in the teaching laboratory, maintenance of equipment including routine checks on the proper operation and condition of all laboratory equipment, and *review and enforcement of safety and security rules*.
- The TA may have other duties necessary to their position (such as those outlined below for a laboratory TA) and will be notified of those duties by their supervisor.
- Any additional summer research support given to a TA may only be used for thesis related research.