Stevens Institute of Technology 2006-2007 Catalog

The Charles V. Schaefer, Jr. School of Engineering

Department of Civil, Environmental, and Ocean Engineering

ALAN F. BLUMBERG, DIRECTOR

FACULTY*

Professors

Alan F. Blumberg, George Meade Bond Professor, Ph.D. (1976), The Johns Hopkins University
Michael S. Bruno, Director Center for Maritime Systems, Sc.D., P.E. (1986), Massachusetts Institute of Technology
Christos Christodoulatos, Director Center for Environmental Systems, Ph.D. (1991), Stevens Institute of Technology
Richard I. Hires, Ph.D. (1968), The Johns Hopkins University
George P. Korfiatis, William H. McLean Professor, Dean of the Charles V. Schaefer, Jr.School of Engineering, Ph.D. (1984), Rutgers University

Associate Professors

Dimitri Donskoy, Ph.D. (1984), Institute of Applied Physics, Gorky (Russia)
Sophia Hassiotis, Ph.D. (1993), Purdue University
Thomas O. Herrington, Ph.D. (1996), Stevens Institute of Technology
Xiaoguang Meng, Ph.D. (1993), Syracuse University
David A. Vaccari, Ph.D., P.E., DEE (1984), Rutgers University

Assistant Professors

Mahmoud Wazne, Ph.D. (2003), Stevens Institute of Technology
X. Frank Xu, Ph.D. (2005), The Johns Hopkins University

Distinguished Service Professors

K. Yusuf Billah, Ph.D. (1989), Princeton University
Henry P. Dobbelaar, Jr., Vice President of Facilities, M.S., P.E. (1968), New Jersey

Travel Directions

Campus Map

Institute of Technology

Research Professors

Alexander Sutin, D.Sc. (1990), Acoustical Institute, Moscow (Russia)

Research Associate Professors

Raju Datla, Ph.D. (1996), Stevens Institute of Technology
Len Imas, Ph.D. (1998), Massachusetts Institute of Technology
Mohammed Sidhoum, Ph.D. (1988), Stevens Institute of Technology
Tsan-Liang Su, Ph.D. (1997), Stevens Institute of Technology

Research Assistant Professors

Washington Braida, Ph.D. (1997), Iowa State University
Jon Miller, Ph.D. (2004), University of Florida
Rustam Stolkin, Ph.D. (2004), University College Londony

Lecturer

Leslie R. Brunell, Ph.D., P.E. (1996), Stevens Institute of Technology

Adjunct Professors

Gregory J. Battista, Esq., J.D., (1986), Seton Hall School of Law
Kevin Bruno, Esq., J.D., (1983), Rutgers School of Law
Russell Ford, Ph.D., P.E. (2003), Stevens Institute of Technology
Roy C. Messaros, Ph.D. (2004), Stevens Institute of Technology
Moh Mohiuddin, Ph.D. (1996), Stevens Institute of Technology
Hormoz Pazwash, Ph.D., P.E. (1970) University of Illinois
Richard Sansone, M.S., P.E., Manhattan College
Sajan Thomas, Ph.D. (1993), Stevens Institute of Technology
Cosmas Tzavelis, Ph.D. (1986), Columbia University
Marty Valerio, M.B.A. (1974), Seton Hall University
Theodore Zoli, M.S. (1990), California Institute of Technology

*The list indicates the highest earned degree, year awarded, and institution where earned.

UNDERGRADUATE PROGRAMS

Civil Engineering

Civil engineering is concerned with constructed facilities, including structures, foundations, environmental and transportation systems, waterways, ports, irrigation, drainage, and water supply and treatment. The civil engineer's vital role is to plan, design, and supervise the construction of these facilities.

Civil engineering is one of the most publicly-visible technical fields. It shares the distinction, with military engineering, of being the earliest of the engineering disciplines. Other branches of engineering emerged as technical knowledge became more specialized. Civil engineering not only retains a strong relationship with the other branches, but continues to generate new areas of technology.

The basic theories of structural analysis, which are the concern of civil engineers, are expressed in every machine and aircraft, and in buildings and other constructed facilities. The study of mechanics is basic to the field of civil engineering. A thorough foundation in science and mathematics is necessary for the application of basic scientific principles to the design of structures and fluid systems. Computer methods are integrated throughout the civil engineering elective offerings.

Graduates of the Stevens program meet the demands for positions of responsibility in various sub-disciplines of civil engineering and contribute to the advancement of the civil engineering practice. Prospective employers include industrial firms, consulting engineering firms, and construction contractors, as well as various government agencies.

Our undergraduate offerings include subjects basic to all civil engineering.

Mission and Objectives

The mission of the civil engineering program at Stevens is to educate a new generation of civil engineers who are leaders in the profession. The educational program emphasizes professional practice, entrepreneurship, leadership, lifelong learning, and civic contribution. The program of study combines a broad-based core engineering curriculum, and a substantial experience in the humanities and in business engineering management, with specialization in civil engineering. Within the sequence of civil engineering courses, students have the flexibility to concentrate in structural, geotechnical, water resources and environmental engineering, or construction management.

The objectives of the civil engineering program are provided in terms of our expectations for our graduates. Within several years of graduation, they will:

- Establish a distinctive record of achievements within the profession and will have become a licensed Professional Engineer;

- Be thoroughly aware and knowledgeable in dealing with environmental, social, ethical, and economic impacts of their projects;
- Augment their knowledge through professional and cultural continuing education;
- Be active in leadership roles within their professional and technical societies;
- Be innovative and creative in conceiving, designing, and constructing a broad range of projects;
- Continue to demonstrate an entrepreneurial spirit in all their activities; and
- Actively support and advance the educational programs at Stevens Institute of Technology.

Course Sequence

The general template of the engineering curriculum for civil engineering is as follows:

Freshman Year					
Term I					
		Hrs. Per Wk.			
		Class	Lab	Study	Sem. Cred.
CH 115	General Chemistry I	3	0	6	3
CH 117	General Chemistry Lab I	0	3	0	1
MA 115	Calculus I	3	0	6	3
E 101	Eng. Experiences I #	1	0	0	0
E 121	Engineering Design I	0	3	2	2
E 120	Engineering Graphics	0	2	2	1
E 115	Intro. to Programming	1	1.5	3	2
HUM	Humanities	3	0	6	3
	# credit applied in E102				
TOTAL		**11**	**9.5**	**25**	**15**

Term II					
		Hrs. Per Wk.			
		Class	Lab	Study	Sem. Cred.
Science	Science Elective I (1)	3	0	6	3
E 102	Eng. Experiences II #	1	0	0	1

MA 116	Calculus II	3	0	6	3
PEP 111	Physics I	3	0	6	3
E 122	Engineering Design II	0	3	3	2
HUM	Humanities	3	0	6	3
	# credit for E101 & 102				
TOTAL		**13**	**3**	**27**	**15**

Sophomore Year					
Term III					
		Hrs. Per Wk.			
		Class	Lab	Study	Sem. Cred.
MA 221	Differential Equations	4	0	8	4
PEP 112	Physics II	3	0	6	3
E 126	Mechanics of Solids	4	0	8	4
E 245	Circuits & Systems	2	3	7	3
E 231	Engineering Design III	0	3	2	2
HUM	Humanities	3	0	6	3
TOTAL		**16**	**6**	**37**	**19**

Term IV					
		Hrs. Per Wk.			
		Class	Lab	Study	Sem. Cred.
MA 227	Multivariable Calculus	3	0	6	3
E 232	Engineering Design IV	2	3	7	3
E 234	Thermodynamics**	3	0	6	3
Science	Science Elective II (1)	2	3	7	3
CE 373	Structural Analysis	3	0	6	3
HUM	Humanities	3	0	6	3
TOTAL		**16**	**6**	**38**	**18**

Junior Year					
Term V					
		Hrs. Per Wk.			
		Class	Lab	Study	Sem. Cred.
CE 342	Transport/Fluid Mech. **	3	3	6	4
E 344	Materials Processing	3	0	6	3

E 321	Engineering Design V	0	3	2	2
E 243	Prob. & Statistics	3	0	6	3
CE 486	Structural Steel Design	3	0	6	3
HUM	Humanities	3	0	6	3
TOTAL		**15**	**6**	**32**	**18**

Term VI					
		Hrs. Per Wk.			
		Class	Lab	Study	Sem. Cred.
CE 345	Modeling & Simulation ‡	3	0	6	3
E 355	Engineering Economics	3	3	6	4
CE 322	Engineering Design VI ‡	1	3	5	2
CE 304	Water Resources Engineering	3	0	6	3
CE 483	Geotechnical Engineering	3	0	6	3
G.E.	General Elective (2)	3	0	6	3
TOTAL		**16**	**6**	**35**	**18**

Senior Year					
Term VII					
		Hrs. Per Wk.			
		Class	Lab	Study	Sem. Cred.
CE 381	Surveying	3	0	6	3
T.E.	Technical Elective ‡	3	0	6	3
G.E.	General Elective (2)	3	0	6	3
CE 423	Engineering Design VII‡	0	8	4	3
T.G.	Technogenesis core**	3	0	6	3
CE 484	Reinforced Concrete Design	3	0	6	3
Total		**15**	**8**	**34**	**18**
Term VIII					
		Hrs. Per Wk.			
		Class	Lab	Study	Sem. Cred.
T.E.	Technical Elective ‡	3	0	6	3
T.E.	Technical Elective ‡	3	0	6	3
G.E.	General Elective (2)	3	0	6	3
CE 424	Engineering Design VIII ‡	0	8	4	3

HUM	Humanities	3	0	6	3
TOTAL		**12**	**8**	**28**	**15**

** Core option – specific course determined by engineering program
‡ Discipline specific course, either CM 501 or CM 580 is allowed
1) Basic Science electives – note: engineering programs may have specific requirements
- one elective must have a laboratory component
- two electives from the same science field cannot be selected
2) General Education Electives – chosen by the student
- can be used towards a minor or option
- can be applied to research or approved international studies

GRADUATION REQUIREMENTS

The following are requirements for graduation of all engineering students and **are not included for academic credit**. They will appear on the student record as pass/fail.

Physical Education

All engineering students must complete a minimum of three semester credits of Physical Education (P.E.). A large number of activities are offered in lifetime, team, and wellness areas. Students must complete at least one course in their FIRST semester at Stevens; the other two can be completed at any time, although it is recommended that this be done within the first half of the student's program of study. Students can enroll in more than the minimum required P.E. for graduation and are encouraged to do so.

- Participation in varsity sports can be used to satisfy the full P.E. requirement.
- Participation in supervised, competitive club sports can be used to satisfy up to two credits of the P.E. requirement with approval from the P.E. Coordinator.

English Language Proficiency

All students must satisfy an English Language proficiency requirement.

PLEASE NOTE: *A comprehensive Communications Program will be implemented for the Class of 2009. This may influence how the English Language Proficiency requirement is met. Details will be added when available.*

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Environmental Engineering

Environmental engineering has traditionally been taught as a branch of civil engineering concerned with the supply of safe drinking water and the sanitary disposal of municipal wastes. The field has expanded in recent years to include many new areas, such as the treatment of industrial and hazardous wastes, the prediction of the fate and transport of pollutants in the environment, and the design of systems for remediation of sites contaminated with hazardous wastes. This has placed new demands on engineers to understand the fundamental environmental transformation processes that describe natural and engineered systems.

Mission and Objectives

The mission of the environmental engineering program is to provide a broad-based education that prepares students in the technical and social fundamentals that will enable them to have a wide impact in the improvement of interactions between humans and their environment.

The objectives of the program are aligned with these expectations for our graduates:

- They will be recognized as being among "the best in the business" by their peers.
- They possess the fundamental understanding of environmental processes that enables them to contribute to any specialty area of environmental engineering.
- They use their knowledge of the design process, reaction mechanisms, and materials balance methods to create innovative solutions to environmental problems.
- They demonstrate exemplary sensitivity to social factors including the historical, legal, political, policy, economic, ethical, and public-relations aspects of environmental problems.
- They solve environmental problems using a systems approach, incorporating interactions with natural, engineered, and social components.
- They address the wider aspects of environmental problems such as sustainability, design for the environment, pollution prevention, and industrial ecology.

Course Sequence

The general template of the engineering curriculum for environmental engineering is as follows:

Freshman Year					
Term I					
		Hrs. Per Wk.			
		Class	Lab	Study	Sem. Cred.
CH 115	General Chemistry I	3	0	6	3
CH 117	General Chemistry Lab I	0	3	0	1
MA 115	Calculus I	3	0	6	3
E 101	Eng. Experiences I #	1	0	0	0

E 121	Engineering Design I	0	3	2	2
E 120	Engineering Graphics	0	2	2	1
E 115	Intro. to Programming	1	1.5	3	2
HUM	Humanities	3	0	6	3
	# credit applied in E102				
TOTAL		**11**	**9.5**	**25**	**15**

Term II					
		Hrs. Per Wk.			
		Class	Lab	Study	Sem. Cred.
CH 116	General Chemistry I	3	0	6	3
E 102	Eng. Experiences II #	1	0	0	1
MA 116	Calculus II	3	0	6	3
PEP 111	Physics I	3	0	6	3
E 122	Engineering Design II	0	3	3	2
HUM	Humanities	3	0	6	3
	# credit for E101 & 102				
TOTAL		**13**	**3**	**27**	**15**

Sophomore Year					
Term III					
		Hrs. Per Wk.			
		Class	Lab	Study	Sem. Cred.
MA 221	Differential Equations	4	0	8	4
PEP 112	Physics II	3	0	6	3
E 126	Mechanics of Solids	4	0	8	4
E 245	Circuits & Systems	2	3	7	3
E 231	Engineering Design III	0	3	2	2
HUM	Humanities	3	0	6	3
TOTAL		**16**	**6**	**37**	**19**

Term IV					
		Hrs. Per Wk.			
		Class	Lab	Study	Sem. Cred.
MA 227	Multivariable Calculus	3	0	6	3
E 232	Engineering Design IV	2	3	7	3

E 234	Thermodynamics**	3	0	6	3
Science	Science Elective II (1)	2	3	7	3
EN 375	Intro. to Envir. Eng. Systems ‡	3	0	6	3
HUM	Humanities	3	0	6	3
TOTAL		**16**	**6**	**38**	**18**

Junior Year					
Term V					
		Hrs. Per Wk.			
		Class	Lab	Study	Sem. Cred.
CE 342	Transport/Fluid Mech. **	3	3	6	4
E 344	Materials Processing	3	0	6	3
E 321	Engineering Design V	0	3	2	2
CHE 210	Process Analysis	3	0	6	3
EN 541	Fate and Transport Env. Cont.‡	3	0	6	3
HUM	Humanities	3	0	6	3
TOTAL		**15**	**6**	**32**	**18**

Term VI					
		Hrs. Per Wk.			
		Class	Lab	Study	Sem. Cred.
EN 345	Modeling & Simulation ‡	3	0	6	3
E 355	Engineering Economics	3	3	6	4
EN 322	Engineering Design VI ‡	1	3	5	2
EN 570	Environmental Chemistry‡	3	0	6	3
EN 571	Physicochemical Processes‡	3	0	6	3
G.E.	General Elective (2)	3	0	6	3
TOTAL		**16**	**6**	**35**	**18**

Senior Year					
Term VII					
		Hrs. Per Wk.			
		Class	Lab	Study	Sem. Cred.
EN 575	Environmental Biology‡	3	0	6	3
EN 573	Biological Processes‡	3	0	6	3
G.E.	General Elective (2)	3	0	6	3

E 423	Engineering Design VII‡	1	7	4	3
T.G.	Technogenesis core**	3	0	6	3
E 243	Probability & Statistics	3	0	6	3
Total		**16**	**7**	**34**	**18**
_					
Term VIII					
		Hrs. Per Wk.			
		Class	Lab	Study	Sem. Cred.
EN 551	Soil Chemistry‡	3	0	6	3
EN 506 or EN 551	Air Pollution Control or Atmospheric Chemistry‡	3	0	6	3
G.E.	General Elective (2)	3	0	6	3
E 424	Engineering Design VIII ‡	1	7	4	3
HUM	Humanities	3	0	6	3
TOTAL		**13**	**7**	**28**	**15**

** Core option – specific course determined by engineering program
‡ Discipline specific course
(1) Basic Science electives – note: engineering programs may have specific requirements
- one elective must have a laboratory component
- two electives from the same science field cannot be selected
(2) General Education Electives – chosen by the student
- can be used towards a minor or option
- can be applied to research or approved international studies

GRADUATION REQUIREMENTS

The following are requirements for graduation of all engineering students and **are not included for academic credit**. They will appear on the student record as pass/fail.

Physical Education

All engineering students must complete a minimum of three semester credits of Physical Education (P.E.). A large number of activities are offered in lifetime, team and wellness areas. Students must complete at least one course in their first semester at Stevens; the other two can be completed at any time, although it is recommended that this be done within the first half of the student's program of study. Students can enroll in more than the minimum required P.E. for graduation and are encouraged to do so.

- Participation in varsity sports can be used to satisfy the full P.E. requirement.
- Participation in supervised, competitive club sports can be used to satisfy up to two credits of the P.E. requirement with approval from the P.E.

Coordinator.

English Language Proficiency

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Changes in the sequence of technical electives are permissible when made in consultation with your faculty advisor. Such changes must be consistent with the departmental guidelines for the environmental engineering curriculum.

Naval Engineering

Naval Engineering is a broad-based engineering discipline that involves the design, construction, operation, and maintenance of surface and sub-surface ships, ocean structures, and shore facilities. Although these vessels and facilities are traditionally employed in the defense of the nation, many are also employed in the support of the civilian (commercial) Marine Transportation System. Because of the complexities of today's naval and civilian vessels and supporting infrastructure, the Naval Engineer must possess a strong background in the physical sciences, mathematics, and modeling, as well as the more specialized fields of naval architecture, marine engineering, systems engineering, and environmental engineering.

Mission and Objectives

The mission of the naval engineering program at Stevens is to develop innovative engineers capable of international leadership in the profession. The educational program emphasizes design innovation, trans-disciplinary study, a systems perspective on complex ship and infrastructure designs, lifelong learning, and opportunities for international study and internships. As is the case for the other Stevens engineering programs, the naval engineering program includes a broad-based core engineering curriculum and a substantial experience in the humanities.

The program is conducted in concert with the Stevens leadership in the Office of Naval Research–sponsored *Atlantic Center for the Innovative Design and Control of Small Ships* and in collaboration with University College London.

The objectives of the naval engineering program are provided in terms of our expectations for our graduates. Within several years of graduation, they will:

- Be recognized as among the most innovative designers and project managers in the world;
- Be thoroughly aware of, and knowledgeable in dealing with, environmental, social, ethical, and economic impacts of their projects;
- Augment their knowledge through professional and cultural continuing education; and
- Be active in leadership roles within their professional and technical societies.

ENGINEERING – Concentration in Naval Engineering

Course Sequence

Freshman Year					
Term I					
		Hrs. Per Wk.			
		Class	Lab	Study	Sem. Cred.
CH 115	General Chemistry I	3	0	6	3
CH 117	General Chemistry Lab I	0	3	0	1
MA 115	Calculus I	3	0	6	3
E 101	Eng. Experiences I #	1	0	0	0
E 121	Engineering Design I	0	3	2	2
E 120	Engineering Graphics	0	2	2	1
E 115	Intro. to Programming	1	1.5	3	2
HUM	Humanities	3	0	6	3
	# credit applied in E102				
TOTAL		**11**	**9.5**	**25**	**15**

Term II					
		Hrs. Per Wk.			
		Class	Lab	Study	Sem. Cred.
Science	Science Elective I (1)	3	0	6	3
E 102	Eng. Experiences II #	1	0	0	1
MA 116	Calculus II	3	0	6	3
PEP 111	Physics I	3	0	6	3
E 122	Engineering Design II	0	3	3	2
HUM	Humanities	3	0	6	3
	# credit for E101 & 102				
TOTAL		**13**	**3**	**27**	**15**

Sophomore Year					
Term III					
		Hrs. Per Wk.			
		Class	Lab	Study	Sem. Cred.
MA 221	Differential Equations	4	0	8	4
PEP 112	Physics II	3	0	6	3
E 126	Mechanics of Solids	4	0	8	4
E 245	Circuits & Systems	2	3	7	3
E 231	Engineering Design III	0	3	2	2
HUM	Humanities	3	0	6	3
TOTAL		**16**	**6**	**37**	**19**

Term IV					
		Hrs. Per Wk.			
		Class	Lab	Study	Sem. Cred.
MA 227	Multivariable Calculus	3	0	6	3
E 232	Engineering Design IV	2	3	7	3
E 234	Thermodynamics**	3	0	6	3
Science	Science Elective II (1)	2	3	7	3
CE 373	Structural Analysis	3	0	6	3
HUM	Humanities	3	0	6	3
TOTAL		**16**	**6**	**38**	**18**

Junior Year					
Term V					
		Hrs. Per Wk.			
		Class	Lab	Study	Sem. Cred.
CE342	Transport/Fluid Mech. **	3	3	6	4
E 344	Materials Processing	3	0	6	3
E 321	Engineering Design V	0	3	2	2
E 243	Prob. & Statistics	3	0	6	3
OE 524	Intro. to Ship Design and Shipbuilding	3	0	6	3
HUM	Humanities	3	0	6	3
TOTAL		**15**	**6**	**32**	**18**

Term VI

		Hrs. Per Wk.			
		Class	Lab	Study	Sem. Cred.
OE 528	Computer Aided Ship Design	3	0	6	3
E 355	Engineering Economics	3	3	6	4
E 322	Engineering Design VI (Ship Design)	1	3	5	2
OE 525	Principles of Naval Architecture	3	0	6	3
OE 620	Marine Structures	3	0	6	3
G.E.	General Elective (2)	3	0	6	3
TOTAL		**16**	**6**	**35**	**18**

Senior Year					
Term VII					
		Hrs. Per Wk.			
		Class	Lab	Study	Sem. Cred.
T.E.	Technical Elective ‡	3	0	6	3
OE 527	Laboratory in Naval Architecture	3	0	6	3
G.E.	General Elective (2)	3	0	6	3
E 423	Engineering Design VII (Ship Design)	1	7	4	3
T.G.	Technogenesis core**	3	0	6	3
OE xxx	Total Ship Design	3	0	6	3
Total		**16**	**7**	**34**	**18**
-					
Term VIII					
		Hrs. Per Wk.			
		Class	Lab	Study	Sem. Cred.
T.E.	Technical Elective ‡	3	0	6	3
OExxx	Total Ship Design	3	0	6	3
G.E.	General Elective (2)	3	0	6	3
E 424	Engineering Design VIII (Ship Design)	1	7	4	3
HUM	Humanities	3	0	6	3
TOTAL		**13**	**7**	**28**	**15**

** Core option – specific course determined by engineering program
‡ Discipline specific course
(1) Basic Science electives – note: engineering programs may have specific requirements
- one elective must have a laboratory component
- two electives from the same science field cannot be selected
(2) General Education Electives – chosen by the student
- can be used towards a minor or option

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GRADUATION REQUIREMENTS

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- Participation in supervised, competitive club sports can be used to satisfy up to two credits of the P.E. requirement with approval from the P.E. Coordinator.

English Language Proficiency

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The naval engineering program is being offered under the Stevens accreditation in general engineering.

Minors

Students may qualify for minors in structural engineering, coastal engineering, water resources, or environmental engineering by taking the required courses indicated below. Completion of a minor indicates a proficiency beyond that provided by the Stevens engineering curriculum in the basic material of the selected area.

Requirements for a Minor in Structural Engineering

CE 373 Structural Analysis
CE 484 Concrete Structures or
CE 519 Advanced Structures
CE 486 Structural Steel Design
CE 681 Finite Elements

Requirements for a Minor in Coastal Engineering

CE 304 Water Resources Engineering

CE 342 Fluid Mechanics
OE 501 Oceanography
OE 589 Coastal Engineering

Requirements for a Minor in Water Resources

CE 304 Water Resources Engineering
CE 342 Fluid Mechanics
CE 525 Engineering Hydrology or
CE 535 Stormwater Management
CE 553 Groundwater Engineering

Requirements for a Minor in Environmental Engineering

CHE 210 Process Analysis
CE 342 Fluid Mechanics
EN 375 Environmental Systems
EN 570 Environmental Chemistry
or
EN 541 Fate and Transport of Environmental Contaminants
EN 571 Physicochemical Processes for Environmental Control
or
EN 573 Biological Processes for Environmental Control

LABORATORIES

Laboratories in the Department of Civil, Environmental, and Ocean Engineering are used for course-related teaching and special problems, design projects and for research. For a complete listing of our laboratories, including the Keck Geoenvironmental Laboratory, the Center for Environmental Engineering, the James C. Nicoll Environmental Laboratory and the Davidson Laboratory, as well as two consortiums in which Stevens holds membership, please refer to the section entitled "Research Environment."

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GRADUATE PROGRAMS

An undergraduate degree in engineering or related disciplines with a "B" average from an accredited college or university is generally required for graduate study in civil, environmental, and ocean engineering. It is required that any applicants requesting assistantship appointments, and applicants to the Ph.D. program, provide GRE scores, as well as evidence of ability to carry out independent work. Examples of such evidence include a description of master's degree thesis work and/or completed work-related projects. GRE scores are not otherwise required, but may be submitted in support of the application. International students must demonstrate their proficiency in the English language prior to admission by scoring at least 550 (213 computer-based) on the TOEFL examination. Applications for admission from qualified students are accepted at any time.

Major areas of current faculty research include earthquake engineering, wind engineering, soil-structure interactions, soil mechanics and deep foundation systems, stochastic aspects of saturated and unsaturated flow modeling, advanced oxidation of hazardous wastes, transport of nonaqueous-phase liquids in the subsurface, statistical process control of wastewater treatment, stabilization/solidification of contaminated soil, residential water conservation, physicochemical treatment of heavy metal contaminated wastes, hydrodynamic modeling of currents and the dispersion of effluents in the coastal zone, experimental and computational marine hydrodynamics, coastal sediment transport, and analysis of current and wave observations in the coastal ocean.

Master's Programs

The Master of Engineering degree is offered with programs in civil, environmental, and ocean engineering. The programs normally require 30 credit-hours of course work. A thesis is optional and may be substituted for five to ten credit-hours of course work. The thesis option is strongly recommended for full-time students, those receiving financial support, or those planning to pursue doctoral studies.

The Master of Science degree program in Maritime Systems provides advanced instruction in the various disciplines associated with maritime ports and ocean and inland waterway transportation systems. This instruction is delivered in a framework that encourages the use of technology to address the social, environmental, and economic issues related to maritime systems. In recognition of the diverse skills required in today's port and marine transportation industries, the program combines a multidisciplinary core curriculum with an array of specialized tracks that provide disciplinary focus.

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Master of Engineering - Civil Engineering

Concentrations are available in the areas of structural and geotechnical engineering. The student must complete core courses depending on the areas of concentration as follows:

Civil Engineering Concentrations

Structural Engineering Core Courses

CE 519 Advanced Structural Analysis
CE 579 Advanced Reinforced Concrete Structures
CE 595 Geotechnical Design
CE 660 Advanced Steel Structures
CE 681 Finite Element Methods

Geotechnical/Geoenvironmental

Engineering Core Courses

CE 595 Geotechnical Design
CE 649 Earth Supporting Structures
EN 520 Soil Behavior and its Role in Environmental Applications
EN 654 Environmental Geotechnology
EN 686 Groundwater Hydrology and Pollution

Water Resources Engineering Core Courses

CE 525 Engineering Hydrology
CE 535 Stormwater Management
CE 684 Mixing Processes in Inland and Coastal Waters
CE 685 Advanced Hydraulics
EN 686 Ground Water Hydrology and Pollution

Hydrologic Modeling Track

CE 526 Watershed Modeling
CE 651 Drainage Design and Modeling
CE 652 Hydrologic Modeling
EN 680 Modeling of Environmental Systems

Stormwater Management Track

CE 527 Wetland Hydrology
CE 591/OE 591 Introduction to Dynamic Meteorology
OE 616 Sediment Transport
CE 650 Water Distribution Systems Analysis

Substitutions for core courses may be considered on a case-by-case basis in consultation with your advisor.

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Master of Engineering - Environmental Engineering

The Environmental Engineering graduate program is divided into three areas of concentration: Environmental Processes, Groundwater and Soil Pollution Control, and Inland and Coastal Environmental Hydrodynamics.

The Environmental Processes concentration addresses the treatment of industrial and domestic water and wastewater and hazardous wastes. Process fundamentals are integrated with a design-based approach to meeting treatment objectives. Students will be prepared for careers in both design and operation of facilities for pollution control.

The Groundwater and Soil Pollution Control concentration emphasizes the transport and fate of contaminants in the subsurface environment and on engineering processes to mitigate their adverse environmental impact. Some specific areas of study in this option are the modeling of contaminant transport in local or regional geohydrologic systems, the impact of contamination in the subsurface environment, the management of municipal and industrial waste disposal, and the remediation of groundwater and soil.

The Inland and Coastal Environmental Hydrodynamics concentration addresses the circulation and mixing processes in surface waters and the effect of such processes on the fate and transport of contaminants. Deterministic, stochastic, and experimental techniques are emphasized.

Major areas of current faculty research include groundwater hydrology and pollution, water and wastewater treatment processes, design of waste disposal management, and environmental processes in coastal and estuarine waters. Master's candidates without a previous engineering degree may, on a case-by-case basis, be allowed to enroll for the Master of Engineering in Environmental Engineering if they have a bachelor's degree in a relevant science discipline. These students must also take CE 503, CE 504, and EN 505, or their equivalent, not for credit towards a degree. All applicants must have at least two years of calculus and one year of chemistry.

Core Courses

CE 565 Numerical Methods for Civil and Environmental Engineering
EN 541 Fate and Transport of Environmental Contaminants
EN 570 Environmental Chemistry

Environmental Engineering Concentrations

Environmental Control Processes

EN 570 Environmental Chemistry
EN 571 Physiochemical Processes for Environmental Control
EN 573 Biological Processes for Environmental Control
EN 575 Environmental Biology
EN 637 Environmental Control Laboratory
EN 751 Design of Wastewater Facilities

Groundwater and Soil Pollution Control

EN 520 Soil Behavior and its Role in

Environmental Applications
EN 551 Environmental Chemistry of Soils
EN 553 Groundwater Engineering
EN 654 Environmental Geotechnology
EN 686 Groundwater Hydrology and Pollution
EN 690 Soil and Groundwater Remediation Technologies

Inland and Coastal Environmental Hydrodynamics

CE 525 Engineering Hydrology
OE 501 Oceanography
OE 616 Sediment Transport

The remaining courses are electives, which are selected in consultation with the academic advisor. Electives may be concentrated in specific areas, including:

Modeling of Environmental Processes

CE 679 Regression and Stochastic Methods
CE 684 Mixing Processes in Inland and Coastal Waters
EN 680 Modeling of Environmental Systems
EN 780 Nonlinear Correlation and System Identification

Water Resources

CE 504 Water Resources Engineering
CE 535 Stormwater Management
CE 685 Advanced Hydraulics

Air Pollution Control

EN 505 Air Pollution Principles and Control
EN 550 Environmental Chemistry of Atmospheric Processes
OE 591 Introduction to Dynamic Meteorology

Environmental Sustainability

EN 545 Environmental Impact Analysis and Planning
EN 547 Project Life Cycle Analysis
EN 548 Environmental Compatibility in Design and Manufacturing

Hazardous Waste Management

EN 549 Environmental Risk Assessment and Management
EN 586 Hazardous Waste Management
EN 587 Environmental Law and Management
EN 618 HAZMAT Spill Response Planning

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Master of Engineering - Ocean Engineering

Advanced courses in the Ocean Engineering graduate program reflect the research interests of the faculty and cover topics in coastal engineering, sediment transport, mixing processes in coastal and estuarine waters, environmental fluid mechanics, estuarine and coastal ocean modeling, motion of vessels in waves, underwater acoustics, and marine meteorology. Basic areas of study encompass oceanography, hydrodynamics, and naval architecture. The master's degree program requires a minimum of two graduate-level applied mathematics courses and satisfaction of the following distributional requirements:

A student must take at least one course in each of the three basic areas of study.

The student must take at least one advanced course in ocean engineering subject areas outside his/her area of concentration.

A typical selection of courses for the master's degree without a thesis in ocean engineering for a student with a concentration, for example, in coastal engineering would encompass the following:

The applied mathematics requirement would be met by taking MA 529 and MA 530.

The basic courses in hydrodynamics, oceanography, and naval architecture could be satisfied with OE 630, OE 501, and OE 525.

The concentration in coastal engineering could include the sequence of OE 641, OE 616, OE 589, and OE 635.

The remaining course could be one of the following:

CE 684 Mixing Processes in Inland and Coastal Waters
OE 539 Underwater Acoustics
OE 642 Motion of Vessels in Waves

which are in subject areas outside of coastal engineering.

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Master of Science - Construction Management

The Construction Management curriculum offers an excellent opportunity for the construction professional and the engineering manager to direct construction firms and projects in an effective, efficient, and professional manner, while dealing with the delicate environmental issues of today's complex marketplace. The program consists of five core and five elective courses of a practical nature, including those dealing with financial, legal, safety, and administrative aspects relevant to the construction industry. Theory is integrated into realistic problems that arise within today's competitive construction arena. The program has been designed with flexibility so that the student's interest in a special area can be satisfied. An undergraduate degree in engineering or related disciplines from a recognized school is a prerequisite for graduate study in construction management.

Core Courses

CM 509 Construction Cost Analysis and Estimating
CM 541 Project Management for Construction
CM 550 Construction Contract Law I
CM 571 Practicum in Construction Management
CM 580 Construction Management I

Master of Science - Maritime Systems

The Maritime Systems program combines a multidisciplinary core curriculum with an array of specialized tracks that provide disciplinary focus. All students in the program must complete ten courses comprised of five core courses and five elective courses selected from one of the four engineering and management tracks listed below. The student, with the approval of the program director, may design a customized track. Up to six elective credits may be taken in lieu of course credits towards a project relevant to the selected track.

The program encourages applicants from diverse backgrounds, including (but not limited to) engineering, ocean sciences, environmental science, and management. Applicants may need to complete prerequisite courses. The specific requirements will be determined by a faculty advisor on an individual basis, depending on the student's educational background and work experience.

Each student will meet with his/her faculty advisor to devise a study plan that matches the student's background, experience, and interests, while also satisfying the formal coursework requirements for the master's degree.

Core Courses

OE 501 Oceanography
OE 505 Introduction to Maritime Systems
OE 610 Marine Transportation
OE 612 Environmental Issues in Maritime Systems
OE 614 Economic Issues in Maritime Systems

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Environmental Engineering Track

Program Directors - Professors Christos Christodoulatos and Xiaoguang Meng.

This concentration offers engineering and environmental professionals the opportunity to pursue advanced study of the environmental issues facing the marine transportation community. Because of the wide range of activities associated with maritime systems, and the fact that most of these activities take place in environmentally-sensitive areas, the instruction is broad-based and addresses the impact of the activities on marine/freshwater, sediment and groundwater resources. Students acquire the skills to address complex engineering problems associated with pollution prevention, waste management and environmental compatibility in design, construction, maintenance and operations.

CM/EN 587 Environmental Law and Management
EN 545 Environmental Impact Analysis and Planning
EN 549 Environmental Risk Assessment and Management
OE/EN 618 HAZMAT Spill Response Planning
CE 684 Mixing Processes in Inland and Coastal Waters

Structural Engineering Track

Program Directors - Professors Michael Bruno and Yusuf Billah

This concentration provides knowledge of the specific structure types and design analyses associated with port systems. Students are given instruction in the various design and maintenance considerations unique to the marine and inland waterway environments. Students acquire skill in using state-of-the-art design tools, including computer and physical models of maritime structures. The Davidson Laboratory's internationally known wave and towing tank facilities are utilized in the delivery of this instruction.

OE 622 Design of Port Structures I
OE 623 Design of Port Structures II
OE 589 Coastal Engineering
MT 533 Environmental Degradation of Materials or
CE 530 Nondestructive Evaluation of Structures
CE 519 Advanced Structural Analysis or
CE 681 Introduction to Finite Element Methods

Management Track

Program Director - Professor Leon Bazil

This concentration provides instruction in key management areas associated with port and marine transportation industries. Students acquire knowledge of the complex global economic environment in which today's port operators and shippers must compete. Experienced management professionals provide relevant analysis tools and management strategies.

Mgt 550 Project Management

Mgt 612 The Human Side of Project Leadership
Mgt 680 Organizational Behavior and Theory
Mgt 657 Operations Management
Mgt 650 International Business Management or
Mgt 641 Marketing Management

Marine Transportation Track
Program Directors - Professors Raju Datla and Michael Bruno

This concentration provides instruction in an array of knowledge areas relevant to safe and effective waterborne transport, a key focus of Stevens' Davidson Laboratory since its founding in 1935. The Laboratory's physical modeling facilities, including the high-speed towing tank and the maneuvering basin, are employed in course instruction.

OE 525 Principles of Naval Architecture
OE 642 Motion of Vessels in Waves
OE 643 Stability and Control of Marine Craft
OE 626 Port Planning and Development
OE 628 Maritime Safety

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Graduate Certificate Programs

The department offers the following programs leading to graduate certificates. Students need to meet regular admissions requirements for the master's program and complete the courses listed below. The courses may also be used toward the Master of Engineering degree (or Master of Science - Construction Management degree*).

Applied Coastal Oceanography

Required:
OE 688 Coastal Ocean Dynamics
OE 535 Oceanographic Measurements and Data Analysis

Choose two from the following list:
OE 591 Dynamic Meteorology
OE 616 Sediment Transport
OE 633 Dynamic Oceanography
OE 637 Estuarine Oceanography
OE 684 Mixing Processes in Inland and Coastal Waters

Atmospheric and Environmental Science and Engineering (Interdisciplinary)

PEP 575 Fundamentals of Atmospheric Radiation and Climate
CE 591 Introduction to Dynamic Meteorology
ME 532/EN 506 Air Pollution Principles and Control
EN 550 Environmental Chemistry of

Atmospheric Processes

Construction/Quality Management*

CM 541 Project Management for Construction
CM 542 Quality Management and Construction Performance
CM 580 Construction Management I
CM 590 Construction Management II

Construction Engineering*

CM 501 Construction Engineering I
CM 502 Construction Engineering II
CM 531 Construction Materials
CM 581 Temporary Structures in Heavy Construction

Construction Accounting/Estimating*

CM 509 Construction Cost Analysis and Estimating
CM 511 Construction Accounting
CM 580 Construction Management I
CM 590 Construction Management II

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Construction Law/Disputes*

CM 522 Labor Relations
CM 550 Construction Contract Law I
CM 551 Construction Contract Law II
CM 587 Environmental Law and Management

Environmental Compatibility in Engineering

EN 505 Environmental Engineering
EN 541 Fate and Transport of Environmental Contaminants
EN 545 Environmental Impact Analysis and Planning
EN 547 Project Life Cycle Management
EN 548 Environmental Compatibility in Design and Manufacturing

Environmental Hydrology

CE 684 Mixing Processes in Inland and Coastal Waters
EN 680 Modeling of Environmental Systems
EN 686 Groundwater Hydrology and Pollution
CE 527 Wetland Hydrology

Environmental Processes

EN 541 Fate and Transport of Environmental Contaminants
EN 570 Environmental Chemistry
EN 571 Physicochemical Processes for

Environmental Control
EN 573 Biological Processes for
Environmental Control

Geotechnical Engineering

CE 520 Soil Behavior and its Role in Environmental Applications
CE 560 Advanced Soil Testing
CE 595 Geotechnical Design
CE 649 Earth Supporting Structures

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Hydraulics

CE 525 Engineering Hydrology
CE 685 Advanced Hydraulics
CE 526 Watershed Modeling
CE 741 Hydraulic Structures

Inland and Coastal Environmental Hydrodynamics

OE 501 Oceanography
EN 541 Fate and Transport of
Environmental Contaminants
CE 684 Mixing Processes in Inland and
Coastal Waters

Multi-Hazard Engineering

CE 576 Multi-Hazard Engineering
CE 578 Coastal and Flood Plain Engineering
CE 626 Earthquake Engineering Design
CE 628 Wind Effects on Structures

Ocean Engineering

Required:
OE 501 Oceanography
OE 589 Coastal Engineering

Choose two from the following list:
OE 620 Marine Structures
OE 630 Hydrodynamics
OE 635 Stochastic Analysis of Ocean Waves
OE 641 Dynamics of Ocean Waves
OE 647 Advanced Hydrodynamics Laboratory

Ship Hydrodynamics

Required:
OE 525 Principles of Naval Architecture
OE 620 Marine Structures

Choose two from the following list:
OE 530 Yacht Design
OE 526 Computer Aided Aspects of Naval
Architecture
OE 642 Motion of Vessels in Waves
OE 645 Hydrodynamics of High Speed Craft
OE 647 Advanced Hydrodynamics Laboratory

Soil and Groundwater Pollution Control

EN 520 Soil Behavior and its Role in Environmental Applications
EN 553 Groundwater Engineering
EN 686 Groundwater Hydrology and Pollution
EN 690 Soil and Groundwater Remediation Technologies

Structural Engineering

CE 613 Matrix Analysis of Structures
CE 519 Advanced Structural Analysis
CE 623 Structural Dynamics
CE 681 Introduction to Finite Element Methods

Surface Water Hydrology

CE 535 Stormwater Management
CE 526 Watershed Modeling
CE 527 Wetland Hydrology
CE 651 Drainage Design and Modeling

Water Resources Engineering

CE 525 Engineering Hydrology or CE 535 Stormwater Management
CE 684 Mixing Processes in Inland and Coastal Waters
CE 685 Advanced Hydraulics
EN 686 Ground Water Hydrology and Pollution

Water Quality Control

EN 571 Physiochemical Processes for Environmental Control
EN 573 Biological Processes for Environmental Control
EN 686 Groundwater Hydrology and Pollution
EN 751 Design of Wastewater Facilities

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Doctoral Program

The program leading to the Doctor of Philosophy degree is designed to develop the student's capability to perform research or high-level design in civil, environmental, or ocean engineering. Admission to the doctoral program is made through the departmental graduate admissions committee, based on review of the applicant's scholastic record. A master’s degree is required before a student is admitted to the doctoral program. One's master’s level academic performance must reflect your capability to pursue advanced studies and perform independent research.

Ninety credits of graduate work in an approved program of study beyond the bachelor’s degree are required for completion of the doctoral program. Up to 30 credits obtained in a master's program can be included in this program. Of the remaining 60 credits, 15 to 30 credit hours of course work, as well as 30 to 45 credit hours of dissertation work, are required. Within two years from the time of admission, a student must take a qualifying examination that tests his/her ability to critically analyze the research literature. Upon satisfactory performance in the qualifying examination, and completion of the required course work, (s)he must take an oral preliminary examination. This examination is primarily intended to evaluate the student's aptitude for advanced research and examine his/her understanding of the subjects associated specifically with the dissertation topics. Upon satisfactory completion of the preliminary examination and all course work, a student will become a doctoral candidate and start his/her dissertation research. Doctoral research work must be based on an original investigation and the results must make a significant, state-of-the-art contribution to the field, and must be worthy of publication in current professional literature. At the completion of the research, a student must defend his/her thesis in a public presentation.

Civil Engineer Degree

To be qualified to enter the civil engineer degree program, a student must have completed a master's degree in engineering. The degree candidate must also demonstrate professional competence by having at least two years of responsible industrial experience in one of the areas of civil engineering. The industrial experience is to be completed prior to entering the program or in the process of being satisfied upon entering the program. Thirty credits beyond the master's degree are required for the degree of civil engineer. Eight to 15 of those credits must be on a design project. A student will be assigned an advisor who will help him/her develop a study plan and who will supervise his/her design project. The study plan, which should include details of the professional experience and of the design project, must be submitted to the departmental committee on the civil engineer degree for approval. Upon completion of the design project, (s)he will submit a written report to the departmental committee for approval, and the student will be required to take an oral examination on the substance of the design project.

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FACILITIES

Keck Geoenvironmental Laboratory

The Keck Geoenvironmental Engineering Laboratory is a fully-equipped new facility for state-of-the-art computer automated geotechnical, as well as environmental, testing of soil and water media. Some of the major equipment available includes: X-ray diffraction capabilities for mineralogical characterizations; scanning electron microscope for surface morphological studies; zeta potential meter for solid surface charge analyses;

integrated wet chemistry facilities to accommodate any type of physicochemical and environmental soil testing, such as particle and pore size distribution, surface area, cation exchange capacity, batch and sequential extraction, oxide content, consolidation, triaxial and direct shear strength testing, flexible and rigid wall permeameters, and CBRs; durability chambers for simulating environmental stresses, such as freeze and thaw, wetting and drying, salt fog and acid rain exposure, as well as other accelerated weathering field conditions; and full sample collection and specimen preparation set-ups.

Some of our current studies involve: testing for the environmental and engineering properties of fly ash, incinerator ash, and other industrial waste-by-product materials to evaluate their use in construction applications; evaluate the properties of dredged materials for reuse in transportation projects; treatment and management of hazardous wastes, focusing on heavy metal and petroleum hydrocarbon immobilization in geoenvironments; study of the fate and transport of contaminants in the subsurface; surface enhancement of currently used industrial wastewater filtration media; development of leaching protocols; etc.

James C. Nicoll Environmental Laboratory (JNEL)

This state-of-the-art facility, administered by CEE, provides diversified research services for the development, testing, transfer, and implementation of innovative environmental technologies. It has multimedia capabilities for wastewater, liquid waste, solid waste, and air studies. Its role is to offer services to industry, government, and environmental professional organizations ranging from short duration, highly-specialized testing, to long-term applied research studies. JNEL's capabilities cover a broad range, including waste stream characterization, process feasibility and waste minimization studies, regulatory acceptance testing for product certification, and environmental compatibility testing of new products.

The laboratory includes a large high-bay process testing laboratory for conducting process experiments and an analytical laboratory equipped with fully-automated instrumentation including gas chromatography/ion-trap mass spectroscopy, high-performance liquid chromatography with diode array detection, and atomic absorption spectrophotometry with both graphite furnace and flame capability.

Center for Maritime Systems (CMS)

The Center for Maritime Systems continues the nearly 75-year-old tradition of the Davidson Laboratory in employing the experimental method to solve complex problems that are otherwise intractable. This approach has been extended to include the physical and numerical modeling of ocean and vessel dynamics, as well as full-scale prototype testing and ocean field observations.

The CMS is a truly unique research and education center that combines the fields of naval architecture, coastal and ocean engineering, physical oceanography, and marine hydrodynamics to create a trans-disciplinary enterprise that can address both the highly-specialized issues confronting each discipline, as well as the more complex, integrated issues facing natural and man-made maritime systems.

The CMS also maintains a 45-foot research vessel fully equipped for environmental studies in the Hudson estuary and adjacent coastal ocean. The vessel is powered by a 400hp Cummins 6 cylinder diesel engine with a 400 gallon fuel capacity. It cruises at 12 kt with a top speed of about 14 kt. Onboard capabilities include a full electronics suite including gps, radar, and chartplotter, a 50 gallon freshwater tank, berths for 3, and an 1500-pound capacity A-frame winch.

Davidson Laboratory

This research division of the department has two towing tanks suitable for model studies for both naval architecture and for coastal engineering applications. These facilities are supported by extensive machine shop, electronics and instrumentation service groups, and design, drafting, and photographic services. Graduate students in the department are encouraged to use the facilities and services of the laboratory in the conduct of their own research.

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UNDERGRADUATE COURSES

CE 304 Water Resources Engineering (3-0-3)

Principles of engineering hydrology, the hydrologic cycle, rainfall-runoff relationships, hydrographs, hydrologic and hydraulic routing, groundwater resources, planning and management of water resources, probabilistic methods in water resources, reservoir design, and water distribution systems. Prerequisite: E 243.

CE/EN 322 Engineering Design VI (1-3-2)

The main objective of the project is to design, construct, and test bench-scale water treatment systems composed of a metallic iron reactor, an aeration tank, and a sedimentation basin. The system should be able to remove phosphate and nitrate from simulated agricultural wastewater to below the discharge limit. The students will learn chemical reactions between metallic iron and pollutants, reduction and oxidation reactions involving iron, and mass transfer of oxygen; perform literature searches; use a spectrophotometer and ion chromatography for phosphate and nitrate analyses; and carry out batch experiments to determine the kinetics of reactions between phosphate, nitrate, and iron filings. The parameters obtained in laboratory experiments will be used to design a full-scale water treatment system.

CE 342 Fluid Mechanics
(3-3-4)
Fluid properties: fluid statics, stability of floating bodies, conservation of mass, the Euler and Bernoulli equations, the impulse-momentum principle, laminar and turbulent flow, dimensional analysis and model testing, analysis of flow in pipes, open channel flow, hydrodynamic lift, and drag. Practical civil engineering applications stressed. Prerequisite: E 126.

CE 345 Modeling and Simulation
(3-0-3)
Introduction to linear systems and eigenvalue problems. Matrix analysis of trusses and frames, stress analysis, and free and forced vibrations of structures. Introduction to nonlinear ODEs and PDEs with applications to civil engineering problems. Use of MATLAB or equivalent to simulate solutions.

EN 345 Modeling and Simulations of Environmental Systems
Development of simple mathematical models for predicting the transport and fate of effluents discharged into lakes, reservoirs, rivers, estuaries, oceans, and groundwater. Formulation of finite difference methods for solving ordinary differential equations and partial differential equations. Role of carbon, nitrogen, and phosphorus cycles.

CE 373 Structural Analysis
(3-0-3)
Shear and bending moment diagrams for beams and frames. Statically determinate trusses influence lines and moving loads, deflection of beams using moment-area and conjugate-beam methods, introduction to energy methods, deflection of beams and frames using unit-load method, introduction to statically indeterminate structures, approximal methods, moment-distribution, and slope-deflection methods. Prerequisite: E 126.

EN 375 Environmental Systems
(3-3-4)
An introduction to environmental engineering, including: environmental legislation; water usage and conservation; water chemistry including pH and alkalinity relationships; solubility and phase equilibria; environmental biology; fate and transport of contaminants in lakes, streams and groundwater; and design and analysis of mechanical, physicochemical, and biochemical water and wastewater treatment processes.

CE 377 The Art of Structural Engineering
(3-0-3)
At its best, creativity in structural engineering leads to forms that are notable for their sculptural and aesthetic quality as much as for their structural intelligence. Structures that express this behavior clearly and elegantly achieve the highest levels of artistic creation,

and become cultural symbols that exceed historical and cultural boundaries. This course explores Art in Structural Engineering as it evolves in modern history, beginning with the Cast Iron bridges of the Industrial Revolution. It progresses through the works of Eiffel, Roebling, Freyssinet, and Maillart to modern-day innovators like Menn, Khan, and Calatrava. Students learn engineering concepts through technical presentations on structural landmarks like the Eiffel Tower, Guggenheim Museum, George Washington Bridge, and the Hearst Tower. The course studies beautiful works of structural art and takes site visits in the metropolitan area to supplement the classroom material. These trips will include the Brooklyn Bridge, Skyscraper Museum, Cast Iron District, Flatiron Building, Guggenheim Museum, and Hearst Building. The course converges engineering, architecture, design, and art into one distinguished field. It teaches the concepts and designs behind structural engineering, so high a quality in imaginative conception and execution, that the engineering itself takes on the aspects of art.
Prerequisite: E126

CE 381 Surveying
(2-3-3)
Use of surveying instruments; measurement of angles, distances, and elevations; field notebook keeping; traverse computations; and topographic data gathering and map making. Construction surveys, horizontal and vertical curves, and slope staking. Introduction to land surveying, photogrammetry, and electronic surveying.

CE 410 Transportation Engineering Design
(3-0-3)
Description of design elements of system components of transportation, including the driver, vehicle, and roadway. Traffic flow design elements including volume, density, and speed. Intersection design elements including delay, capacity, and accident counter-measures. Terminal design elements.

CE/EN 423-424 Engineering Design VII-VIII
(0-8-3) (0-8-3)
Senior design courses. Complete design sequence with a required capstone project spanning two semesters. While the focus is on the capstone disciplinary design experience, it includes the two-credit core module on E 421 Engineering Economic Design during the first semester.

CE 483 Geotechnical Engineering
(3-3-4)
Elementary concepts of engineering geology and solid mechanics: applications to the solution of design problems, classification of soils, theory of soil strength, lateral pressure and retaining walls, slope stability, stress distribution theory and settlement predictions, bearing capacity and design of shallow foundations, seepage analysis, consolidation theory, and laboratory tests. The course is accompanied by concurrent weekly laboratory

sessions where students are introduced to the basic concepts of geotechnical testing in a hands-on fashion. Prerequisite: E 126.

CE 484 Reinforced Concrete Design (3-0-3)
Ultimate strength design for bending and shear of rectangular sections, slabs, "T" sections and continuous beams, girders, columns, retaining walls, and footings. Code requirements. Prerequisite: CE 373.

CE 486 Structural Steel Design (3-0-3)
Design of steel structures according to the latest specifications, tension and compression members, beams, beam-columns, connections, composite beams, design examples, bridges, building frames, and footings. Prerequisite: CE 373.

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GRADUATE COURSES

All Graduate courses are 3 credits except where noted.

Civil Engineering

CE 503 Engineering Hydraulics
Properties of fluids, fluid statics, mass, energy and momentum conservation principles, flow in pipes, major and minor energy losses, and water pumps. Principles of flow in open channels, uniform flow computations, gradually varied flows, design of hydraulic structures, dimensional analyses, and similitude principles.

CE 504 Water Resources Engineering
Principles of engineering hydrology, the hydrologic cycle, rainfall-runoff relationships, hydrographs, and hydrologic and hydraulic routing. Ground water resources. Planning and management of water resources. Probabilistic methods in water resources, reservoir design, and water distribution systems.

CE 518 Advanced Mechanics of Materials
A second course in Mechanics of Materials that will introduce failure criteria, energy methods, beams on elastic foundations, curved beams, asymmetric bending, buckling, and the theory of elasticity. The emphasis is on classical problems and solutions without numerical procedures. Prerequisite: E 126 or equivalent.

CE 519 Advanced Structural Analysis
Elementary structural analysis from an advanced viewpoint. Statically indeterminate structures; and the Flexibility Method, the Moment Distribution Method, and the Slope Deflection Method. Energy methods in structural engineering; and virtual work and deformation calculations. Potential energy and its minimization; and the Rayleigh-Ritz method and an introduction to the Finite Element method. Arch and cable analysis. Plasticity

and Limit State design. The Theory of Thin Plates. Introduction to Stiffness analysis of structures. Miscellaneous topics in structural analysis, such as, plates on elastic foundation. Prerequisite: CE 373 or equivalent.

CE 520 Soil Behavior and its Role in Environmental Applications
An overview of soil mineralogy, soil formation, chemistry and composition. Influence of the above factors in environmental engineering properties; study of colloidal phenomena; fate and transport of trace metals in sediments, soil fabric and structure; conduction phenomena; compressibility, strength, deformation properties, stress-strain-time effects, as they pertain to environmental geotechnology applications (i.e., contaminated soil remediation, soil/solid waste stabilization, waste containment alternatives, soil-water-contaminant interactions, contaminant transport). Prerequisite: An undergraduate introductory course in geotechnical engineering. Cross-listed with EN 520.

CE 525 Engineering Hydrology
Principles of hydrology and their application to engineering projects, including the hydrologic cycle, measurement and interpretation of hydrologic variables, stochastic hydrology, flood routing, and computer simulations in hydrology.

CE 526 Watershed Modeling
This course is intended to provide graduate students with the tools necessary to simulate the water quality of a complex watershed. The course will focus on the development of models for examining the water quality and water quantity issues that are associated with watershed management. Students will learn various modeling technologies from simplistic mass balance models to more complex dynamic models. The models required for fully understanding the effects of both point and nonpoint sources of pollution on a natural waterway will be examined. The students will also develop an understanding of how to design a monitoring program to collect the data that are appropriate for simulating a natural system. Current state and federal guidelines and regulations will be discussed, including the development of a wasteload allocation for a point source, a load allocation for a nonpoint source, and a Total Maximum Daily Load (TMDL) for an impaired waterway. This course will not only provide the student with the tools necessary to simulate a watershed, but also provide a keen insight into the watershed management process. The final project will require the students to work in teams to analyze a specific watershed.

CE 527 Wetland Hydrology
Over the past two decades, there has been a rise in wetland mitigation projects across the country. The success of a wetland depends mainly on its hydrology. Central to the course will be the principle of water budgeting. This course will outline the hydrologic

principles involved in freshwater and coastal wetland engineering. Dynamic and steady state mathematical modeling will be presented as techniques to estimate wetland hydrology.

CE 530 Nondestructive Evaluation
This course will introduce principles and applications of Nondestructive Evaluation (NDE) techniques which are important in design, manufacturing, and maintenance. Most commonly used methods such as ultrasonics, magnetics, radiography, penetrants, and eddy currents will be discussed. Physical concepts behind each of these methods, as well as practical examples of their applications will be emphasized. Cross-listed with ME 521.

CE 535 Stormwater Management
This course will be of significant importance in urban planning and construction management. The management of stormwater must be addressed for any modern development/construction project. This course will focus on the development of the runoff hydrograph, the design of storm drains and detention ponds, watershed characteristics for the existing developed areas, and regulations by both state and federal agencies.

CE 541 Project Management for Construction
This course deals with the problems of managing a project. A project is defined as a temporary organization of human and nonhuman resources, within a permanent organization, for the purpose of achieving a specific objective. Both operational and conceptual issues will be considered. Operational issues include definition, planning, implementation, control, and evaluation of the project; conceptual issues include project management vs. hierarchical management, matrix organization, project authority, motivation, and morale. Cases will include construction management, chemical plant construction, and other examples. Cross listed with CM 541. Prerequisite: CM 511 or permission of the instructor.

CE 560 Advanced Soil Testing
An advanced treatment of methods and techniques of soil testing. It entails the execution of tests, data presentation, and data interpretation associated with soil mechanics practice and research. Tests include soil classification, compaction, shear strength, permeability soil-moisture extraction, and soil compressibility. Use of microcomputers in data reduction and presentation.

CE 565 Numerical Methods for Civil and Environmental Engineering
An introduction to numerical analytical methods applied to civil and environmental engineering. Methods for solution of nonlinear equations, systems of linear equations, interpolation, regression, and solution of ordinary and partial differential equations. Applications include trusses, beams, river oxygen balances, and adsorption isotherms. Several computer projects are

required. Prerequisite: knowledge of a procedural computer program language (C++, FORTRAN, etc.).

CE 576 Multi-Hazard Engineering
Identification and assessment of wind, flood, earthquake, surge, wave, tsunami, erosion, subsidence and landslide hazards and their associated loading on the built environment. Comprehensive engineering and planning techniques presented to mitigate extreme loads generated by individual and multi-hazards in the natural environment.

CE 578 Coastal and Flood Plain Engineering
Identification, assessment, and risk analysis of river and coastal flood hazards. Introduction to flood plain analysis, surge, and overland wave propagation. Development of flood, surge, and wave load analysis. Presentation of flood hazard mitigation techniques and engineering design of flood proofing techniques.

CE 579 Advanced Reinforced Concrete Structures
Ultimate Strength Design of beams, deep beams, slender columns, walls, two-way, and plate slabs. Study of bending, shear, torsion, deflections, shrinkage, creep, and temperature effects. Code Requirements. Prerequisite: CE 484.

CE 591 Introduction to Dynamic Meteorology
This course presents a cogent explanation of the fundamentals of atmospheric dynamics. The course begins with a discussion of the Earth's atmospheric system, including global circulation, climate, and the greenhouse effect. Basic conservation laws and the applications of basic equations of motion are discussed in the context of synoptic scale meteorology. The thermodynamics of the atmosphere are derived based on the equation of state of the atmosphere with specific emphasis on adiabatic and pseudo-adiabatic motions. The concept of atmospheric stability is presented in terms of the moist and dry lapse rates. The influence of the planetary boundary layer on atmospheric motion is presented with an emphasis on topographic and open ocean frictional effects, temperature discontinuity between land and sea, and the generation of sea breezes. The mesoscale dynamics of tornadoes and hurricanes are discussed, as well as the cyclogenesis of extratropical coastal storms. The course makes use of a multitude of web-based products including interactive learning sites, weather forecasts from the National Weather Service (NWS), tropical predictions from the National Hurricane Center, and NWS model outputs (AVN, NGM, ETA, and WAM). Cross-listed with OE 591.

CE 595 Geotechnical Design
A design-oriented course in which geotechnical engineering principles are applied to the computer-aided design of shallow and pile foundations, bulkheads, and retaining walls. The course also deals with advanced soil mechanics concepts as applied to the determination of lateral earth pressures needed for the design of retaining

walls. Prerequisite: An undergraduate introductory course in geotechnical engineering.

CE 601 Theory of Elasticity
Review of matrix algebra; the strain tensor, including higher order terms; the stress tensor; derivation of the linear form of Hooke's law and the higher order form of Hooke's law; equilibrium equations, boundary conditions and compatibility conditions; applications to the bending and torsion problems. Variational methods. Stress Concentration. Curred and Deep Beam Theory.

CE 607 Theory of Elastic Stability
Buckling failure of beams, columns, plates, and shells in the elastic and plastic range; postbuckling strength of plates; and application of variational principles.

CE 608 Theory of Plates and Shells
Elements of two- and three- dimensional elasticity. Fourier Series. Plate bending theories. Rectangular and circular plates with different boundary conditions. Energy methods for plate bending. Numerical methods to solve plate equations; and finite difference and finite element methods. Membrane stresses in shells. Bending theory of shells. Application of shell theory for important structural systems.

CE 613 Matrix Analysis of Structures
Formulation of structural theory based on matrix algebra; discussion of force method and displacement method; use of matrix transformation in structural analysis; and application to indeterminate structures, space frames, and computer applications. Prerequisite: knowledge of computer programming.

CE 621 Bridge Design for Structural Engineers
This course will concentrate on typical highway bridge design and analysis. The design will be based on the current AASHTO specifications and other applicable codes. Major topics will include detailing and seismic design considerations. In addition, emphasis will be placed on inspection procedures and the development of contract plans, specifications, and construction cost estimating. Grading for the course will be based on a midterm exam and a comprehensive design project. Included in the scope of the project will be the design of the superstructure and substructure, the development of influence lines, and a construction cost estimate. Prerequisites: CE 483, CE 484, and CE 486 or equivalents.

CE 623 Structural Dynamics
Introduction to theory of structural dynamics with an emphasis on civil engineering problems. One-degree systems; lumped parameter and multi-degree systems; approximate methods; and analysis and design applications using computers.

CE 626 Earthquake Engineering Design
Introduction to earthquake; its causes and effects; and

seismology and seismic waves. Design codes (UBC, BOCA, and AASHTO). Vibration of structures under ground motion. Dynamics of single- and multi-degree of freedom structures under earthquake loading. Response Spectrum method in seismic analysis. Inelastic response of structures. Earthquake-resistant design of building structures and building codes and structural dynamics. Effect of earthquake on steel and concrete structures. Seismic design of highway bridges. Miscellaneous topics on the effects of earthquake, such as liquefaction. One advanced topic on the effects of earthquake selected by each student in consultation with the instructor.

CE 628 Wind Effects on Structures
Wind characteristics; deterministic and stochastic response; static wind effects and building codes; effects of lateral forces; dynamic effects; self-excited motion, flutter, galloping, and vortex-induced vibration; tornado and hurricane effects; and case studies on tall buildings, long-span bridges, etc.

CE 640 Prestressed Concrete
Basic concepts of prestressing, partial loss of prestress, flexural design, shear, torsion, camber, deflection, indeterminate prestressed structures, connections, and prestressed circular tanks.

CE 648 Numerical Hydrodynamics*
Potential flows around bodies: panel singularities methods and conformal mapping methods. Finite-difference and spectral methods for Poisson equations: numerical inversion of matrices, and potential flows in or around irregular domains. Consistency, stability, and convergence of numerical methods: linear stability analysis. Numerical methods for diffusion equations: methods for ordinary differential equations. One-dimensional Burger's equation: nonlinear problems, Newton iteration, and error analysis. Numerical methods for stream function vorticity equations: flows in or around irregular domains. Current research in computational fluid dynamics: discussions. Four exercise projects and one examination project will be assigned to each student. Prerequisite: Computer Programming. Cross-listed with OE 648.

CE 649 Earth Supporting Structures
A course of lectures dealing with the design, performance, and quality control of earth supporting structures. It includes an outline of the available methods of evaluating slope stability by field studies, numerical computer analysis, and hand calculations. Finally, the last portion of the course covers the principles involved in the design and construction of earth and rockfill dams, including such topics as soil compaction, hydraulic fill dams design criteria, seepage control, slope stability analyses, seismic design, and case history studies. Prerequisite: an undergraduate introductory course in geotechnical engineering.

CE 650 Water Distribution Systems Analysis

The design of an effective and proper system for the distribution of potable water for domestic, institutional, commercial, and industrial use requires an understanding of the principles of planning, design, and construction of pipe networks. This course will focus on the critical elements of planning, design and modeling of a water distribution system.

CE 651 Drainage Design and Modeling
Drainage design includes watershed analysis combined with hydrologic and hydraulic computations. The basic laws of drainage design will be discussed, including the environmental, and economic implications. Regulations pertinent to the area will also be addressed. Concepts of open channel, pressure, and gravity flow will be discussed. Mathematical and computer models will be used to educate the engineer in the techniques available in industry. These models, combined with the mathematical principles presented, will aid the engineer in developing the best possible design for a particular region.

CE 652 Hydrologic Modeling
Water is probably the most used, the most abused, and the most taken-for-granted natural resource. Few people realize what is involved in the planning and building of urban water-distribution and management systems. Environmental costs must also be considered when analyzing any water resources project. Efforts continue toward conservation and environmental protection, which increases the need for engineers to be educated in the behavior of water as it moves through the water cycle. This course will address the modern-day hydrologic processes, the mathematical and scientific processes for hydrology, and introduce several models commonly used in industry. These models will aid the engineer in analyzing the hydrologic processes of a particular region and help provide the best solution for a very sensitive issue.

CE 654 Environmental Geotechnology
The objective of the course is to provide the students with exposure to the geotechnical nature of environmental problems. The topics covered include: principles of geochemistry, contaminant transport and hydrogeology; an overview of landfill liners and other disposal facilities and their design, construction, safe operation, performance monitoring, structural and physiochemical stability; an overview of the general principles governing the design, implementation and monitoring of existing remediation technologies with special emphasis on stabilization/solidification, vapor extraction, bioremediation, soil washing, pump and treat, cover systems and alternative containment systems such as slurry walls. A concurrent laboratory section introduces the student to the chemical analyses, absorption behavior, mineralogical and crystallographical identification and characterization of various waste forms as they pertain to surface chemistry considerations. The

main emphasis of the course consists of providing hands-on experience with analyses involving the use of spectrometric, X-ray diffraction and scanning electron microscope equipment. Prerequisite: EN 520 or equivalent. Cross-listed with EN 654.

CE 660 Advanced Steel Structures
Elastic and plastic design of structural steel systems, residual stresses, beam columns, built-up columns, and compression members with elements that exceed normal width-thickness ratios, torsion of structural sections, plate girders, composite steel-concrete members, introduction to load, and resistance factor design.

CE 679 Regression and Stochastic Methods
An introduction to the applied nonlinear regression, multiple regression, and time-series methods for modeling civil and environmental engineering processes. Topics include: coefficient estimation of linear and nonlinear models; construction of multivariate transfer function models; modeling of linear and nonlinear systems; forecast and prediction using multiple regression and time-series models; statistical quality-control techniques; and ANOVA tables and analysis of model residuals. Applications include monitoring and control of wastewater treatment plants, hydrologic-climatic histories of watercourses, and curve-fitting of experimental and field data. Prerequisite: introductory course in probability and statistics.

CE 681 Introduction to Finite Element Methods
A concise introduction for advanced undergraduate and graduate engineering students. Includes numerical discretization, variational principles, weighted residual methods, Galerkin approximations, continuous and piecewise-defined basis functions, finite-element methods, computer coding of one-dimensional problems, triangular elements - coding of two-dimensional problems, and time-dependent problems.

CE 682 Design of Hydraulic Equipment
This course will provide an understanding of the hydraulic equipment design associated with integrated water and wastewater facilities. Topics include manifold pipe flow, sludge flow, multiport diffusers, open channel flow, flow measurement, hydraulic control points, chemical feed hydraulics, pump and valve selection and hydraulics, and use of computer tools for pump selection and sizing.

CE 684 Mixing Processes in Inland and Coastal Waters
Development of advective-diffusion equations for conservative and non-conservative substances. Fickian diffusion, turbulent diffusion, and shear flow dispersion. Description and specification of mixing processes in rivers, reservoirs, and estuaries. Methods and analyses of conservative dye tracer studies. Monte Carlo simulations of diffusion processes and numerical models for simulation of advection diffusion processes in rivers and estuaries.

CE 685 Advanced Hydraulics
Fundamentals of open channel flows; types of open channels and their properties; and velocity distribution in open channels. Specific energy, momentum, and specific force principles; critical flows; and principles of uniform flow and its computation. Gradually varied flow; channel transitions and controls. Rapidly varied flow; and hydraulic jump and energy dissipaters. Unsteady flows, waves and wave propagation, and flood routing. Applications of numerical methods in hydraulic engineering.

CE 741 Hydraulic Structures
This course will focus on the design of hydraulic structures including small dams, spillways, weirs, and culverts. These are complex structures, the design of which must account for the water forces which act upon them, as well as their impacts upstream and downstream. Structural topics will be covered, along with backwater curves and downstream effects. Models such as the U.S. Army HEC II and HEC RAS will be used, to model the associated hydraulic impacts of these structures. Structural models will also be used where appropriate, to assist in the design of the structures. Environmental and economic implications of hydraulic structures will also be addressed. Prerequisites: CE 525 and CE 685.

CE 746 Advanced Soil Mechanics
Advanced topics in soil mechanics and geotechnology. Application of theory of elasticity to geotechnical problems; two- and three-dimensional consolidation theories; and settlement analysis, and strength of soils. Prerequisite: CE 595 or equivalent.

CE 780-781 Special Topics in Civil and Environmental Engineering I-II
An advanced seminar course concerned with recent research developments in civil engineering. Areas of concentration can be in Structures, Geotechnical, Earthquake, or Environmental Engineering. The topics are subject to current faculty and student interests. The student must have completed certain prerequisite courses and can enroll only with the consent of the instructor.

CE 800 Special Problems in Civil Engineering
One to six credits. Limit of six credits for the degree of Master of Engineering (Civil).

CE 801 Special Problems in Civil Engineering
A thorough investigation of an advanced research topic under the direction of a faculty member. The course is open to students who are or plan to be doctoral candidates. One to six credits for the degree of Doctor of Philosophy.

CE 802 Special Problems in Civil Engineering
One to six credits. Limit of six credits for the degree of

Civil Engineer.

CE 900 Thesis in Civil Engineering
For the degree of Master of Engineering (Civil). Five to 10 credits with departmental approval.

CE 950 Civil Engineering Project*
Design project for the degree of Civil Engineer. Eight to 15 credits.

CE 960 Research in Civil Engineering*
Original research of advanced level in Civil Engineering, which may serve as the topic for the dissertation for the degree of Doctor of Philosophy.

*By request.

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Construction Management

CM 501 Construction Engineering I
This course is a study of construction industry customs, practices, and methods from project conception to close-out. Equipment usage, construction estimating, scheduling, and management techniques are woven into the fabric of this course.

CM 502 Construction Engineering II
This course provides the student in the construction field with a practical analysis and study of the completed construction facility. Case studies are discussed along with the performance of the constructed facility and elements of possible failure within the completed facility. Alternate solutions are discussed, along with their economic feasibility.

CM 505 Construction Safety Management
Various aspects of construction areas and the necessary design and safety techniques are discussed along with building a corporate culture of zero accidents, planning for high project safety performance, establishing accountability for safety, and maintaining a safety communication network. Safety agendas contained within the Total Quality Management Process and the Partnering Process are discussed using actual job case studies. Prerequisite: CM 502, CM 542, CM 581, or CE 595.

CM 506 Computer Applications in the Construction Process
Today's construction manager and engineer should have a thorough knowledge of the latest technology and methods so that various elements within the construction process can be produced, analyzed, and reviewed in an efficient manner. The course gives the construction executive the tools to provide proper planning and scheduling, estimating, cost accounting, cost reports, and other valuable and necessary information in a rapid and professional manner. Prerequisite: CM 501, CM 509, or CM 580.

CM 508 Transportation Engineering
A description of and introduction to the major areas of transportation engineering planning and management which deals with roadways, streets, and highways and the people and vehicles that interact with each other. Topics of discussion include land use, energy, transportation economics, and transportation systems management, along with the traditional areas of traffic engineering. Open-ended problem solving using practical case examples is stressed.

CM 509 Construction Cost Analysis and Estimating
This course provides the construction-orientated professional with the analysis tools and methodology to organize and prepare an accurate construction estimate. Topics include development of productivity data, analysis, and applications of historical data, break-even and cost-to-complete analysis and the study and analysis of job cost reporting systems as they relate to the construction estimate. Estimating methods and systems will be discussed, along with field trips and practical case studies.

CM 511 Construction Accounting
This course presents the principles of accounting for construction projects. Topics include elements of cost accounting, project accounting, and financial analysis used by the construction manager.

CM 512 Problems in Heavy Construction
The general superintendent, engineering staff, and construction manager, in order to manage, schedule, and complete the heavy construction project, must be aware of problems associated with the completion of the complex project. Problems associated with pile driving and shoring, excavation methods, tunneling, trenchless technology, and rock excavation are reviewed. Examples and case studies are discussed, with alternate solutions reviewed based on site conditions and economic considerations. Prerequisite: CM 509.

CM 521 Construction Organizations
This course provides the student with an understanding of human behavior, including individual and group performance, motivation, leadership, and industrial relations. Next, the student will examine various theories of management and the basic functions of planning, organizing, leading, and controlling. This body of knowledge will be applied to the management of construction companies and projects.

CM 522 Labor Relations
This course provides the student with a basic understanding of the practices involved in construction labor relations. Topics include the discussion of union and open shop contractors, job site agreements, collective bargaining and local union negotiations, double-breasted construction operations and termination of the labor agreement, along with case studies in selected areas.

CM 531 Construction Materials
This lecture course covers civil engineering materials, their properties, and their construction use. Specifics to be discussed include physical and mechanical properties of steel, concrete, asphalt, wood, plastic, timber, and soil. Coverage of ASTM standard tests covering these properties is also presented.

CM 541 Project Management for Construction
This course deals with the problems of managing a project. A project is defined as a temporary organization of human and nonhuman resources, within a permanent organization, for the purpose of achieving a specific objective. Both operational and conceptual issues will be considered. Operational issues include definition, planning, implementation, control and evaluation of the project; conceptual issues include project management vs. hierarchical management, matrix organization, project authority, motivation, and morale. Cases will include construction management, chemical plant construction, and other examples. Prerequisite: CM 511 or permission of the instructor. Cross-listed with CE 541.

CM 542 Quality Management and Construction Performance
This course presents the principles and techniques of total quality management (TQM), with emphasis on its application to construction projects and firms. Students will form teams to apply TQM concepts and techniques to construction projects/firms.

CM 543 Construction Contract Management
This course deals with and discusses in detail the complex set of relationships that are involved when a construction project is undertaken. The course also reviews these relationships and how they interact with the planning, administration, start-up, and completion of the project. Risk in the construction project is discussed as it relates to the management and successful completion of the project, while also reviewing the legal relationships that can evolve during the project duration. Prerequisite: CM 511, CM 541, or CM 580.

CM 545/EN 545 Environmental Impact Analysis and Planning
The impact of engineering projects on the physical, cultural, and socioeconomic environment, preparation of environmental impact statements, regulatory framework, and compliance procedures will be discussed. Topics include: major federal and state environmental regulations, environmental impact analysis and assessment, risk assessment and risk management, and regulatory compliance.

CM 550 Construction Contract Law I
This course introduces the principle areas of construction law and contracts. Areas of discussion include contract formulation, scope of work, changes, delays, no damage for delays, insurance and sureties, completion,

termination, and claims and dispute resolutions. Case studies are presented with class presentations and discussions.

CM 551 Construction Contract Law II: Claims and Disputes
This course presents a review and analysis of the methods used in presenting and solving construction contract disputes. Topics of discussion include the origins of the construction dispute, the contract documents, design deficiency, construction schedule, construction of the project, and resolving the dispute. Prerequisite: CM 550.

CM 571 Practicum in Construction Management
This will be a capstone course taken at the end of a student's program of studies. The students will be organized into construction management groups.

CM 580 Construction Management I
This course provides a survey and study of the management process for domestic and international contracting business enterprises. Topics of discussion include the roles of the construction manager, bonds and insurance elements of the estimating process, finance and cost control, labor relations, and work culture.

CM 581 Temporary Structures in Heavy Construction
This course is a study of the elements and concepts of temporary supportive structures involved with heavy construction process. Topics of discussion will include codes, construction, cofferdams, temporary sheeting and bracing, falsework and shoring, and concrete form design.

CM 587 Environmental Law and Management
This course addresses a survey of legal and regulatory approaches to environmental protection. Topics include: environmental ethics, the National Environmental Policy Act, state and federal environmental agencies; and the Clean Water Act, the Safe Drinking Water Act, Superfund, the Resource Recovery and Conservation Act, Right-to-know, the Environmental Cleanup Responsibility Act, and wetlands protection. Cross-listed with EN 587.

CM 590 Construction Management II
This course discusses the principles of construction marketing and strategic planning. Marketing engineering and construction company services and products are discussed with an eye towards the most economical and competitive sales techniques. Case studies and practical applications are presented for class analysis and discussion.

CM 800 Special Problems in Construction Management*
One to six credits. Limit of six credits for the degree of Master of Science.

CM 900 Thesis in Construction Management (M.S.)*

Five to ten credits with departmental approval.

*By request.

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Environmental Engineering

EN 504 Basics of Air Pollution Assessment
The fundamentals of air pollution assessment will be covered. USEPA regulations concerning air emissions and measurement, including the original Clean Air Act of 1990, as well as the update of this regulation, and the requirements of and appendices A, B, and F will be studied. Air measurement associated with ambient air, indoor air, hazardous waste sites, mobile sources, and point sources will be covered. Newer optical sensing methodologies to assess area and volume source emissions and for air toxic compound measurement will be introduced. Completion of this course will provide the student with an introduction to all applications of air and source monitoring and the regulations that drive air measurement.

EN 505 Environmental Engineering
An introduction to environmental engineering, including: environmental legislation; water usage and conservation; water chemistry including pH and alkalinity relationships, solubility, and phase equilibria; environmental biology; fate and transport of contaminants in lakes, streams, and groundwater; design and analysis of mechanical, physicochemical, and biochemical water and wastewater treatment processes.

EN 506 Air Pollution Principles and Control
An introduction to the principles and control of air pollution, including: types and measurement of air pollution; air pollution chemistry; atmospheric dispersion modeling; compressible fluid flow; particle dynamics; ventilation systems; inertial devices; electrostatic precipitators; scrubbers; filters; absorption and adsorption; combustion; and condensation. Cross-listed with ME 532.

EN 520 Soil Behavior and its Role in Environmental Applications
An overview of soil mineralogy, soil formation, chemistry, and composition. Influence of the above factors in environmental engineering properties; study of colloidal phenomena; fate and transport of trace metals in sediments, soil fabric, and structure; conduction phenomena; and compressibility, strength, deformation properties, and stress-strain-time effects, as they pertain to environmental geotechnology applications (i.e., contaminated soil remediation, soil/solid waste stabilization, waste containment alternatives, soil-water-contaminant interactions, and contaminant transport). Prerequisite: An undergraduate introductory course in geotechnical engineering. Cross-listed with CE 520.

EN 541 Fate and Transport of Environmental Contaminants
Description of fundamental processes in natural and engineered systems, including intermedia transport of contaminants between environmental compartments (air, water, soil, and biota) and chemical and biochemical transformations within these compartments.

EN 545 Environmental Impact Analysis and Planning
The impact of engineering projects on the physical, cultural, and socioeconomic environment, and preparation of environmental impact statements, regulatory framework, and compliance procedures. Topics include: major federal and state environmental regulations, environmental permitting processes, environmental impact analysis and assessment, risk assessment and risk management, and regulatory compliance.

EN 547 Project Life Cycle Management
This course addresses the environmental management of engineering projects from the research through the development, operation, maintenance, and ultimate disposal phases. Topics include: impacts of exploitation of raw materials and energy resources and transportation; pollution from use and ultimate disposal of products; and economics of environmental resources.

EN 548 Environmental Compatibility in Design and Manufacturing
The purpose of this course is to teach engineers how to incorporate environmental principles in the design and manufacturing of various products and engineering systems. Topics include: economics and cost-benefit analysis, pollution prevention, recycling, concurrent design, facility citing, risk perception, and case studies.

EN 549 Environmental Risk Assessment and Management
There is little doubt that the different types of risk assessment - health, safety, and ecological - are playing an increasingly important role in environmental decision-making and risk management. Guided by several examples and case studies, participants in this course learn to understand the basic concepts of environmental hazards and the different types of risk assessment. The student will conduct human health risk assessments and appreciate the wide array of applications, as well as the advantages and limitations of risk assessments; interpret and present the results of risk assessments to provide linkages with risk management; and apply the principles of integrated risk management.

EN 550 Environmental Chemistry of Atmospheric Processes
An introduction to the science underlying the description of atmospheric processes and air pollution control, including: composition of atmosphere; sources,

transport, and fate of pollutants; chemical and photochemical reactions; properties of aerosols and effects of air pollution on climate and water; and adsorption, absorption, filtration, and chemical destruction pollutants in air pollution control systems.

EN 551 Environmental Chemistry of Soils and Natural Surfaces
Soil is a mixture of inorganic and organic solids, air, water, and microorganisms. Soil affects the environmental chemistry through the interactions at solution-solid and air-solid interfaces, and the soil in turn is affected by the environmental and human activities. Soil science is not only important to agriculture, but also to diverse fields, such as environmental engineering, biogeochemistry, and hydrology. This course will enable students to understand the chemical properties of soil, soil minerals, natural surfaces, and mechanisms regulating solute chemistry in soil solutions. The fate and transport of inorganic and organic pollutants in soil and soil remediation technologies are discussed. One year of introductory chemistry is required for students who want to take this course.

EN 553 Groundwater Engineering
Fundamental and advanced topics in groundwater engineering analysis and design. Aquifers and well aquifer relationships; aquifer tests by well methods; in situ permeability determination; and flow nets. Seepage principles and seepage control measures; filter and drain design; and computer methods in groundwater engineering.

EN 570 Environmental Chemistry
Principles of environmental reactions with emphasis on aquatic chemistry; reaction and phase equilibria; acid-base and carbonate systems; oxidation-reduction; colloids; organic contaminants classes, sources, and fates; groundwater chemistry; and atmospheric chemistry.

EN 571 Physicochemical Processes for Environmental Control
A study of the chemical and physical operation involved in treatment of potable water, industrial process water, and wastewater effluent; topics include chemical precipitation, coagulation, flocculation, sedimentation, filtration, disinfection, ion exchange, oxidation, adsorption, flotation, and membrane processes. A physical-chemical treatment plant design project is an integral part of the course. The approach of unit operations and unit processes is stressed.

EN 573 Biological Processes for Environmental Control
Biological basis of wastewater treatment; river systems and wastewater treatment works analogy; population dynamics; food sources; aerobic and anaerobic systems; reaction kinetics and parameters affecting waste removal; fundamentals of mass transfer and gas

transfer; trickling filter, and activated sludge process; aerated lagoons; stabilization ponds; nitrification; denitrification; sludge concentration; aerobic sludge digestion; anaerobic sludge digestio and sludge conditioning; sludge drying, vacuum filtration; and incineration and ocean disposal. A biological treatment plant design project is an integral part of the course.

EN 575 Environmental Biology
A survey of biological topics concerning the environment: ecology, population dynamics, pollution microbiology, aquatic biology, bioconcentration, limnology, stream sanitation, nutrient cycles, and toxicology.

EN 586 Hazardous Waste Management
A comprehensive introduction to hazardous waste management, including laws and regulations, identification and analysis, risk assessment, and techniques and technologies for control and treatment.

EN 587 Environmental Law and Management
A survey of legal and regulatory approaches to environmental protection. Topics include: environmental ethics, National Environmental Policy Act, State and Federal environmental agencies; and the Clean Water Act, Safe Drinking Water Act, Superfund, Resource Recovery and Conservation Act, Right-to-Know, Environmental Cleanup Responsibility Act, and wetlands protection. Cross-listed as CM 587.

EN 618 HAZMAT Spill Response Planning
This course is designed to introduce students to the state-of-the-art techniques in spill response planning. Numerical and analytical techniques for the prediction of fate and effects of in-water spills are discussed. Spill cleanup technologies are introduced, including mechanical (e.g., booms and skimmers), chemical (e.g., dispersants), and biological. Students are instructed in the essential steps toward developing an effective spill response plan. Special attention is paid to the influence of spill characteristics and environmental factors - waves, currents, shoreline geometry, sensitive ecological areas, etc. - in the selection of an appropriate planning strategy. Examples are given of existing spill response plans in the New York/New Jersey region, and case studies of actual spills are discussed as a means of providing students with an understanding of the complexities of operational spill response planning. Cross-listed with OE 618.

EN 637 Environmental Control Laboratory
Laboratory verification of the theoretical concepts involved in sampling and analysis of unit operation and unit processes for environmental pollution control and conservation. It is a primarily laboratory course with four lectures presenting the principles and applications of contemporary instrumental analytical methods. Laboratory practice explores ultraviolet, visible, and infrared spectrophotometer; total organic analyzer and atomic absorption spectroscopy; inductively coupled plasma optical emission spectroscopy; and gas-liquid and

high-performance liquid chromatography and mass spectrometry. These instrumental techniques are utilized for quantitative and qualitative analyses of organic, inorganic, biological, and environmental samples.

EN 654 Environmental Geotechnology
The objective of the course is to provide the students with exposure to the geotechnical nature of environmental problems. The topics covered include: principles of geochemistry, contaminant transport, and hydrogeology; an overview of landfill liners and other disposal facilities and their design, construction, safe operation, performance monitoring, structural, and physicochemical stability; an overview of the general principles governing the design, implementation, and monitoring of existing remediation technologies with special emphasis on stabilization/solidification, vapor extraction, bioremediation, soil washing, pump and treat, cover systems, and alternative containment systems such as slurry walls. A concurrent laboratory section introduces the student to the chemical analyses, absorption behavior, mineralogical, and crystallographical identification and characterization of various waste forms as they pertain to surface chemistry considerations. The main emphasis of the course consists of providing hands-on experience with analyses involving the use of spectrometric, X-ray diffraction, and scanning electron microscope equipment. Prerequisite: EN 520 or equivalent. Cross-listed with CE 654.

EN 680 Modeling of Environmental Systems
Incorporation of fundamental reaction and transport phenomena into mass balances to describe the fate and transport of contaminants in lakes, rivers, estuaries, groundwater, the atmosphere, and in pollution-control processes. Several computer projects involving numerical solutions of models are required. Prerequisites: CE 565 and EN 541.

EN 686 Groundwater Hydrology and Pollution
Fundamental concepts in groundwater hydrology and pollution, occurrence, and movement of groundwater; flow nets; well hydraulics; and numerical methods in groundwater hydraulics. Chemical properties of groundwater, sources, and effects of contamination; principles of mathematical modeling of containment transport in groundwater; and numerical methods in groundwater pollution.

EN 690 Soil and Groundwater Remediation Technologies
This course covers state-of-the-art topics on groundwater pollution control and remediation, such as in situ, physical, chemical, and biological treatment, fixation, vitrification, steam, and air stripping and other emerging technologies. Groundwater pollution prevention and management of groundwater quantity and quality issues are addressed. Students are expected to critique recent published papers and make class presentations on selected groundwater quality management issues on a

weekly basis. Prerequisite: EN 686.

EN 751 Design of Wastewater Facilities
Principles of process design and economics are integrated through open-ended problem-solving situations. Topics include process selection, feasibility studies, equipment design and scale-up, costing and economics, optimization, process identification and control, operation and maintenance, and permitting and other regulatory issues. Prerequisites: EN 571 and EN 573.

EN 771 Advanced Environmental Separation Processes
Advanced topics in separation processes for environmental applications in the mass and energy transfer areas. Topics include distillation, absorption, stripping, membrane-based separation processes, thermal destruction of hazardous wastes, supercritical fluid extraction for soils and solid wastes, utilization and development of computer models for process plant design, optimization, and simulation.

EN 780 Nonlinear Correlation and System Identification
An investigation of tools to identify nonlinear processes and relationships. Mathematical tools covered include nonlinear regression, artificial neural networks, and multivariate polynomial regression. Applications include mass transfer correlations, prediction of drinking water quality, and modeling of wastewater treatment processes. Prerequisites: CE 679 or equivalent, and permission of instructor.

EN 800 Special Problems in Environmental Engineering*
One to six credits. Limit of six credits for the degree of Master of Engineering (Environmental).

EN 801 Special Problems in Environmental Engineering*
A thorough investigation of an advanced research topic under the direction of a faculty member. The course is open to students who are or plan to be doctoral candidates. One to six credits for the degree of Doctor of Philosophy.

EN 900 Thesis in Environmental Engineering*
For the degree of Master of Engineering (Environmental). Five to ten credits with departmental approval.

EN 960 Research in Environmental Engineering*
Original research of advanced level in Environmental Engineering which may serve as the topic for the dissertation for the degree of Doctor of Philosophy. Credits to be arranged.

*By request.

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Nanotechnology

NANO 600 Nanoscale Science and Technology
This course deals with the fundamentals and applications of nanoscience and nanotechnology. Size-dependent phenomena, ways and means of designing and synthesizing nanostructures, and cutting-edging applications will be presented in an integrated and interdisciplinary manner.

Ocean Engineering

OE 501 Oceanography
Geophysical description of the earth; the extent, shape. and structure of ocean basins; relief of the sea floor; chemistry of sea water; geochemical balances; physical properties of water and sea water; solar and terrestrial radiation; evaporation and precipitation over the oceans; dissolved gases in sea water; distribution of variables;and general oceanic circulation.

OE 503 Seminar in Ocean Engineering
Seminar course in which you report on selected topics in ocean engineering. Emphasis is on the problems encountered in performing engineering tasks in the ocean and methods employed to surmount them. Students are encouraged to devise alternate methods to improve existing techniques.

OE 505 Introduction to Maritime Systems
An introductory course intended to acquaint students with the various components of maritime systems, including shorefront and inland infrastructure and waterborne (vessel) transportation technologies. Students are introduced to the concepts of port and marine terminal design, cargo handling equipment and optimization, and intermodal transportation networks. The course emphasizes the application of new and emerging technologies to enhance port productivity, drawing on developments within an array of fields, including naval architecture, civil and ocean engineering, and systems engineering. Students are provided with practical examples of the application of these concepts in actual port design projects.

OE 524 Introduction to Ship Design and Ship Building
Overview of maritime industry; types and purposes of commercial and naval ships; introduction to various disciplines of naval engineering; concepts of hydrostatics, resistance, and propulsion; overview of ship systems and general arrangements; introduction to towing tanks and model testing methodology; overview of preliminary ship design with brief group design project; and basics of ship building, operation, repair, and maintenance.

OE 525 Principles of Naval Architecture
Basic principles and design calculations in naval architecture; terminology, delineation of hull form, loading and stability, trim, and effects of flooding; freeboard and tonnage regulations; introduction to design

of hull structure; nature of resistance and its variation with hull form and proportions; and introduction to propellers and propulsion. Basic theories in maneuvering and sea-keeping characteristics, computer application in naval architecture, and ship design.

OE 526 Computer-Aided Aspect of Naval Architecture*
Basic principles and design calculations in naval architecture as an extension of OE 525 PNA course with emphasis placed on the application of computers. Computer-aided studies of hull-forms, intact stability, damaged stability, resistance and propulsion characteristics, course-keeping analysis, and ship motion predictions. Problems in the area of naval architecture will be considered on computers through time-sharing systems.

OE 527 Laboratory in Naval Architecture*
Solution of problems in naval architecture through model testing, actually conducting a wide variety of model tests at Davidson Laboratory, and prediction of prototype performance.

OE 528 Computer-Aided Ship Design*
Computer-aided design procedures to achieve mission requirements for various ship types through design spirals. Determination of major dimension and performance analysis during preliminary design stage. Computer graphics on mainframe and microcomputers as design tools. Pertinent design procedures are covered in a computer-aided manner.

OE 530 Yacht Design*
Calculation of hydrostatic curves to determine trim and sinkage of sailing yachts, static and dynamic stability, calculation of resistance and side force by expansion of tank test results, sail force coefficients, prediction of comparative performance based on tank test results, application of lifting surface theory to the design of keel and rudder, and consideration of structural strength and stiffness. Prerequisite: OE 525 or equivalent.

OE 535 Ocean Measurements and Analysis
Basic ocean measurements and instrumentation, sampling requirements, data processing, analysis, and presentation. Prerequisite: Completion of an undergraduate probability and statistics course.

OE 539 Introduction to Underwater Acoustics
Applications of underwater acoustics; wave equation; plane, spherical, and cylindrical waves; transmission and reflection of sound waves; ray acoustics; radiation and reception of sound; monopole and dipole sources; acoustic array; sound propagation in deep and shallow ocean; passive and active sonars; the sonar equation; transmission loss; ambient noise in the ocean; and target strength.

OE 550 Environmental Acoustics and Acoustical

Remote Environmental Monitoring
The course is intended to acquaint students with environmental acoustics and the application of acoustic waves to remote environmental monitoring. Students will learn how to measure and suppress environmental noise and how underwater acoustic systems are used for remote measurements of various ocean and river parameters, including: bottom profile, surface waves, current, bubble and fish density, etc. The course also surveys recent developments in acoustic tomography, including global warming control. Students will be asked to write a research paper on the application of acquired methods to remote acoustic measurements conducted at Stevens. Prerequisite: OE 539 or instructor's permission.

OE 589 Coastal Engineering
An introductory course covering the fundamental principles of coastal engineering. The initial stages of the course are intended to provide an understanding of the physics of the coastal environment. Topics will include basic wave theory (wave generation, refraction, diffraction, and shoaling), wave prediction techniques, tides and coastal circulatio, and sediment transport. The latter stages of the course will be devoted to the application of these basic principles, such as stabilization and harbor development. The course will culminate in a substantial design project, which will incorporate all aspects of the course material, ranging from the estimation of design wave conditions to the actual design of a shore protection structure. Prerequisite: MA 227 or the equivalent, Fluid Mechanics.

OE 591 Introduction to Dynamic Meteorology
Introduction to meteorology presents a cogent explanation of the fundamentals of atmospheric dynamics. The course begins with a discussion of the Earth's atmospheric system, including global circulation, climate, and the greenhouse effect. The basic conservation laws and the applications of the basic equations of motion are discussed in the context of synoptic scale meteorology. The thermodynamics of the atmosphere are derived based on the equation of state of the atmosphere, with specific emphasis on adiabatic and pseudo-adiabatic motions. The concept of atmospheric stability is presented, in terms of the moist and dry lapse rate. The influence of the planetary boundary layer on atmospheric motions is presented with emphasis on topographic and open ocean frictional effects, temperature discontinuity between land and sea, and the generation of sea breezes. The mesoscale dynamics of tornadoes and hurricanes are discussed, as well as the cyclogenesis of extratropical coastal storms. The course makes use of a multitude of web-based products, including interactive learning sites, weather forecasts from the National Weather Service (NWS), tropical predictions from the National Hurricane Center, and NWS model outputs (AVN, NGM, ETA, and WAM). Cross-listed with CE 591.

OE 610 Marine Transportation
This course introduces students to the history and technical description of the cargo-carrying vessel. Students are given instruction in the basic principles of vessel design, and the various types of ocean-going and inland waterway cargo vessels. Issues related to the introduction of new vessel types are discussed, particularly as these new designs affect port infrastructure and capacity, harbor dredging requirements, and the intermodal transportation network.

OE 612 Environmental Issues in Maritime Systems
An introductory course intended to familiarize students with the array of environmental issues related to inland, estuarine, and oceanfront port facilities. Particular attention is paid to water quality and bottom sediment contamination problems associated with the construction and operation of port facilities. Students are introduced to the various types of analysis tools, including field measurements and computer models, employed in the examination of port and harbor environmental problems. Practical examples of their use are provided from actual projects in the New York/New Jersey region. Students are also instructed in the use of emerging technologies in the prevention/remediation of identified pollution problems. Relevant state, federal, and international regulations are also discussed.

OE 614 Economic Issues in Maritime Systems
This course introduces students to the unique economic issues facing today's port developers and operators. The economic considerations essential to the efficient movement of cargo from vessels to inland transportation systems are discussed. Students are introduced to concepts related to the optimization of port manpower, energy, and infrastructure as a means of assuring competitiveness in the global marketplace. Students are also introduced to the principles of port financial strategies, with examples given from port authorities in the United States and abroad.

OE 616 Sediment Transport
Theory of sediment transport in open channel flow, including applications to riverine, ocean, and coastal environments. Topics covered include boundary layer dynamics, the initiation of motion, sediment characteristics, suspended load, and bed load. Applications include the estimation of transport rates in waves and currents, and the influence of hydraulic structures.

OE 618 HAZMAT Spill Response Planning
This course is designed to introduce students to the state-of-the-art techniques in spill response planning. Numerical and analytical techniques for the prediction of fate and effects of in-water spills are discussed. Spill cleanup technologies are introduced, including mechanical (e.g., booms and skimmers), chemical (e.g., dispersants), and biological. Students are instructed in

the essential steps toward developing an effective spill response plan. Special attention is paid to the influence of spill characteristics and environmental factors - waves, currents, shoreline geometry, sensitive ecological areas, etc. - in the selection of an appropriate planning strategy. Examples are given of existing spill response plans in the New York/New Jersey region, and case studies of actual spills are discussed as a means of providing students with an understanding of the complexities of operational spill response planning. Cross-listed with EN 618.

OE 620 Design of Marine Structures
This course is intended to provide a detailed understanding of the design process in coastal engineering, including the statistical evaluation of oceanographic and meteorological forces and the use of physical and computer models in the assessment of design performance. The essential features of the design of several types of coastal structures will be presented, along with the relevant design relations and/or publicly available design software. The potential environmental impacts of the construction of the various coastal structures considered will also be discussed. A series of case studies and a comprehensive design project provide the opportunity to apply the principles examined. Prerequisites: undergraduate fluid mechanics, statics and dynamics, or equivalent.

OE 622 Design of Port Structures I
This course introduces students to the fundamentals of port structures design, including design codes, guidelines, and functional requirements. Students are instructed in optimization procedures for port and marine terminal layout, including issues related to navigation channels and dredging, shore infrastructure and utilities, land reclamation, and environmental and economic considerations. Structural, geotechnical, and materials considerations are discussed for a variety of environmental conditions, including extreme wave and current environments, ice, and seismic loading. Examples and case studies from actual port design projects are utilized to a great extent in the delivery of the course material.

OE 623 Design of Port Structures II
This course instructs students in the functional design of the various components of ports and marine terminals, including steel, concrete, timber, and stone structures. Students are introduced to the detailed design procedures for a variety of structure types, including bulkheads and piers, fender and mooring systems, and breakwaters and revetments. Special considerations such as sedimentation/dredging, structure inspection and rehabilitation, vessel motions, and port downtime are discussed. Students receive instruction in the use of computer and physical model studies in support of structure design. Environmental and permitting issues are discussed.

OE 626 Port Planning and Development

This course introduces students to the evaluation and optimization of port and harbor layout from the standpoint of safe and efficient vessel navigation and cargo loading and unloading. Students receive instruction in the analysis tools and procedures used in the assessment of vessel motions, while underway in open water and in navigation channels, and while at dock. The evaluation of long wave motions and harbor resonance problems are discussed, as is risk-based analysis of port and harbor protection (e.g., breakwaters). Students will be introduced to computer models used in the evaluation of these issues, and will make extensive use of the models in the conduct of in-class case studies of port and harbor layouts.

OE 628 Maritime Safety
This course introduces students to the various safety issues of concern to port management officials, including those related to cargo (e.g., oil spills) and those related to vessel traffic (e.g., collisions). Students receive instruction in the procedures required for the identification, prevention, and mitigation of problems associated with the various threats to the sensitive marine environment and to the safe passage of cargo-carrying vessels. Students are introduced to the concepts of risk assessment, contingency planning, vessel traffic management systems, and spill response planning. State, federal, and international regulations and guidelines related to maritime safety are discussed. Case studies from the New York/New Jersey region and other port regions are employed in the delivery of this instruction.

OE 630 Hydrodynamics
Development of the kinematic and dynamic equations for incompressible fluid flow, the Navier-Stokes equation, velocity potential and stream function, Bernoulli’s equation, conformal mapping, free surface flows, wave theory, flow in porous media, and turbulence. Prerequisites: MA 227 or equivalent and CE 342.

OE 631 Fluid Dynamics for Ocean Engineering
Cavitation, two-dimensional flows, complex velocity and complex potential; and concentrated and distributed singularities, lift-drag Kutta condition, D’Alembert paradox, Blasius theorem,and Karman vortex street. Conformal mapping, Möbius transformation, Schwartz-Christoffel transformation. Applications, added mass and virtual mass, Taylor’s added mass theorem, Lagally's theorem, the Navier-Stokes equation, exact solutions for parallel flow, Couette flow, and Poiseuille flow. Unsteady problems: boundary layer Reynold's number, flat plate boundary layer, Von Karman integral method, and Pohlhausen solution. Prerequisite: OE 630.

OE 633 Dynamic Oceanography
Gravity and rotation of earth, continuity considerations, dynamic equations of motion, gradient currents, stationary accelerated currents, turbulence, analysis of temperature-salinity diagrams, internal friction and

modification of geostrophic currents, wind-driven currents, and horizontal circulation of wind-driven current

OE 634 Air-Sea Interactions: Theory and Measurement*
Momentum, heat and water flux across the air-sea interface, shear stress and the neutral wind profile, adiabatic lapse rate in the lower atmosphere, static and dynamic stability of a stratified fluid, effects of stability on transfer processes in the lower atmosphere and ocean surface layer, direct measurement of eddy flux, and indirect determination of eddy flux from routine shipboard meteorological observations. Prerequisite: OE 633.

OE 635 Stochastic Analysis of Ocean Waves
Introduction to probability theory; statistical techniques for characterizing random variables and evaluation of data; statistical techniques for analyzing stochastic processes; and application of power spectral density techniques to the representation of the sea surface and other stochastic marine processes.

OE 636 Topics in the Application of Stochastic Process Theory in Ocean Engineering*
An expansion upon three important topics introduced in OE 205. The first topic is random data reduction and interpretation in ocean engineering; and basic methods of auto- and cross-spectral analysis, statistical errors, design of experiments, and directional-wave spectra estimation. The second deals with the application of probabilistic design methods in ocean engineering; and the third is a survey of the state-of-the-art marine applications of nonlinear random process theory. Prerequisite: OE 635.

OE 637 Estuarine Oceanography
Classification of estuaries, salt balance equation, forms of the salt balance equation for major types of estuaries, equations of motion, estuarine circulation, diffusion, and dispersion in estuaries. Prerequisite: OE 633.

OE 641 Dynamics of Ocean Waves
Description and formulation of wave problems in the ocean, development of classical wave theory, free waves and forced waves induced by pulsating and uniformly translating pressures and sources in steady and unsteady states, diffraction, refraction and reflection of waves, application to floating breakwaters, and harbor oscillations.

OE 642 Motion of Vessels in Waves
Dynamic response of a ship in regular and irregular seas, the equation of motion with six degrees of freedom, added mass and damping coefficient of an oscillating ship on the free surface, coupled equation of motion of a ship in waves, and description of ship motion in the irregular sea with the discussion leading to nonlinear equations of motion. Prerequisite: OE 641.

OE 643 Stability and Control of Marine Craft*
Basic concepts of stability and automatic control, equations of motion of marine craft, representation of hydrodynamic forces and moments, equilibrium conditions and perturbation equations, stability criteria, Routh-Hurwitz method, directional stability and maneuvering control, effects of wind, waves and restricted waters, stability of towed bodies, anti-rolling and anti-pitching control systems, and dynamic simulations of marine systems.

OE 644 Design of Ship Propellers*
Fundamentals of two-dimensional flow about hydrofoils, including design of camber lines for specified pressure distributions and the inverse problem, characteristics of thickness distribution, predictions of cavitation inception as a function of thickness, camber, and departure from ideal angle of attack. Three-dimensional flows about lifting signs of large and small aspect ratios. Momentum theory applied to propellers to determine ideal efficiency, lifting line, and lifting surface models of propellers. The use of openwater design charts for the determination of optimum pitch, diameter, and revolutions. Exercise of computer program for preliminary design. Introduction to concepts leading to assessment of vibratory forces and hull forces. Prerequisites: OE 525 and OE 630.

OE 645 Hydrodynamics of High-Speed Marine Craft*
Planing craft, life, drag, wetted area of hull, appendage drag, direct and indirect propeller effect, spray formation, impact loads in smooth water and waves, porpoising, rough water behavior, andtank test procedures.

OE 647 Advanced Hydrodynamic Laboratory*
Several of the important theories germane to ocean engineering are reviewed or developed and used to predict body or fluid behavior. These predictions are then compared with results obtained by the student using the Davidson Laboratory research facilities. Prerequisites: OE 525, OE 527, OE 630, and OE 641.

OE 648 Numerical Hydrodynamics*
Potential flows around bodies: panel singularities methods and conformal mapping methods.
Finite-difference and spectral methods for Poisson equations: numerical inversion of matrices, and potential flows in or around irregular domains. Consistency, stability, and convergence of numerical methods: linear stability analysis. Numerical methods for diffusion equations and methods for ordinary differential equations. One-dimensional Burger's equation and nonlinear problems, Newton iteration, error analysis. Numerical methods for stream function vorticity equations: flows in or around irregular domains. Discussions of current research in computational fluid dynamics. Four exercise projects and one examination project will be assigned to each student. Prerequisite: Computer Programming. Cross-listed with CE 648.

OE 688 Coastal Ocean Dynamics I*
Mechanics of rotating flow; inviscid shallow-water theory: topographic Rossby Waves; effects of friction: the Ekman theory; and wind-driven ocean circulation: coastal ocean modeling, supercomputing applications, dispersion, and mixing in coastal waters. Prerequisites: MA 529 and OE 501 or the equivalent.

OE 690-691 Special Topics in Ocean Engineering I, II*
An advanced seminar course concerned with recent research developments in ocean engineering. Special emphasis will be placed on developments in theoretical and applied hydrodynamics. Topics are subject to the currents interest of the faculty and students. Prerequisites: OE 630, OE 631.

OE 800 Special Problems in Ocean Engineering*
One to six credits. Limit of six credits for the degree of Master of Engineering (Ocean).

OE 801 Special Problems in Ocean Engineering*
One to six credits. Limit of six credits for the degree of Doctor of Philosophy.

OE 900 Thesis in Ocean Engineering*
Five to ten credits with departmental approval for the degree of Master of Engineering (Ocean).

OE 960 Research in Ocean Engineering*
Original basic research of high level design in ocean engineering which may serve as the basis for the dissertation for the degree of Doctor of Philosophy. Credits to be arranged.

*By request

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