

# The Charles V. Schaefer, Jr. School of Engineering

## Department of Civil, Environmental and Ocean Engineering

**HANK P. DOBBELAAR, DIRECTOR**

### **FACULTY\***

#### **Professors**

Alan F. Blumberg, Ph.D. (1976), The Johns Hopkins University  
Michael S. Bruno, P.E., Sc.D. (1986), Massachusetts Institute of Technology  
Christos Christodoulatos, Ph.D. (1991), Stevens Institute of Technology  
Richard I. Hires, Ph.D. (1968), The Johns Hopkins University  
George P. Korfiatis, Ph.D. (1984), Rutgers University

#### **Associate Professors**

K. Yusuf Billah, Ph.D. (1989), Princeton University  
Dimitris Dermatas, Ph.D. (1992), University of California, Berkeley  
Dimitri Donskoy, Ph.D. (1984), Institute of Applied Physics, Gorky (USSR)  
Sophia Hassiotis, Ph.D. (1993), Purdue University  
Xiaoguang Meng, Ph.D. (1993), Syracuse University  
David A. Vaccari, P.E., Ph.D. (1984), Rutgers University

#### **Distinguished Service Professor**

Henry P. Dobbelaar, Jr., P.E., M.S. (1968), New Jersey Institute of Technology

#### **Research Associate Professors**

Raju Datla, Ph.D. (1996), Stevens Institute of Technology  
Thomas O. Herrington, 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  
Mahmoud Wazne, Ph.D. (2003), Stevens Institute of Technology

#### **Research Assistant Professor**

Washington Braid, Ph.D., (1997), Iowa State University

#### **Lecturer**

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

#### **Adjunct Professors**

Battista, Esq. (1986) J.D. Seton Hall School of Law  
Kevin Bruno, Esq. (1983) J.D. Rutgers School of Law  
Russell Ford, Ph.D., P.E. (2003) Stevens Institute of Technology  
Michael W. King, A.A.S (1981) Middlesex County College  
Hormoz Pazwash, Ph.D., P.E. (1970) University of Illinois  
Kelly L. Rankin, Ph.D. (1997), Stevens Institute of Technology  
Richard Sansone, M.S., P.E., Manhattan College  
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 engineers' 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 responsible positions 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, a substantial experience in the humanities and in business engineering management, with specialization in civil engineering. Within the sequence of civil engineering courses, the 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 typical course sequence for civil engineering is as follows:

**Freshman Year**

		<b>Term I</b>		
		Hrs. Per Wk.		
		Class	Lab	Sem.
		Cred.		
Ch 107	General Chemistry IA	2	0	2
Ch 117	General Chemistry Lab I	0	3	1
Ma 115	Math Analysis I	3	0	3
PEP 101	Physics I	3	0	3
E 121	Engineering Design I	0	3	2
E 120	Engineering Graphics I	0	2	1
E 115	Intro to Programming	1	1.5	2
Hu	Humanities	3	0	3
PE 200	Physical Education I	0	2	1
<b>TOTAL</b>		<b>12</b>	<b>11.5</b>	<b>18</b>

		<b>Term II</b>		
		Hrs. Per Wk.		
		Class	Lab	Sem.
		Cred.		
Ch 116	General Chemistry II	3	0	3
Ch 118	General Chemistry Lab II	0	3	1
Ma 116	Math Analysis II	3	0	3
PEP 102	Physics II	3	0	3
E 122	Engineering Design II	0	3	2
E 126	Mechanics of Solids	4	0	4
Hu	Humanities	3	0	3
PE 200	Physical Education II	0	2	1
<b>TOTAL</b>		<b>16</b>	<b>8</b>	<b>20</b>

**Sophomore Year**

		<b>Term III</b>		
		Hrs. Per Wk.		
		Class	Lab	Sem.
		Cred.		
Ma 221	Differential Equations	4	0	4
PEP 201	Physics III	2	0	2
PEP 211	Physics Lab for Engin.	0	3	1
E 234	Thermodynamics	3	0	3
E 245	Circuits & Systems	2	3	3
E 231	Engineering Design III	0	3	2
Hu	Humanities	3	0	3
PE 200	Physical Education III	0	2	1
<b>TOTAL</b>		<b>14</b>	<b>11</b>	<b>19</b>

**Term IV**

		Hrs. Per Wk.		
		Class	Lab	Sem.
		Cred.		
Ma 227	Multivariate Calculus	3	0	3
E 246	Electronics & Instrument.	3	0	3
E 232	Engineering Design IV	0	3	2
E 243	Prob. & Statistics	3	0	3
CE 373	Structural Analysis	3	0	3
Hu	Humanities	3	0	3
PE 200	Physical Education IV	0	2	1
<b>TOTAL</b>		<b>15</b>	<b>5</b>	<b>18</b>

**Junior Year****Term V**

		Hrs. Per Wk.		
		Class	Lab	Sem.
		Cred.		
CE 342	Transport/Fluid Mech	3	3	4
E 344	Materials Processing	3	0	3
E 321	Engineering Design V	0	3	2
CE 381	Surveying	2	3	3
CE 486	Structural Steel Design	3	0	3
Hu	Humanities	3	0	3
PE 200	Physical Education V	0	2	1
<b>TOTAL</b>		<b>14</b>	<b>11</b>	<b>19</b>

**Term VI**

		Hrs. Per Wk.		
		Class	Lab	Sem.
		Cred.		
CE 345	Modeling & Simulation	3	0	3
E 355	Engineering Economics	3	3	4
CE 322	Engineering Design VI	1	3	2
CE 483	Geotechnical Engineering	3	3	4
CE 484	Reinforced Concrete Design	3	0	3
Hu	Humanities	3	0	3
PE 200	Physical Education VI	0	2	1
<b>TOTAL</b>		<b>16</b>	<b>11</b>	<b>20</b>

**Senior Year****Term VII**

Hrs. Per Wk.

		Class	Lab	Sem. Cred.
	Civil Eng. Elective ‡	3	0	3
	Civil Eng. Elective ‡	3	0	3
	Elective	3	0	3
CE 423	Engineering Design VII <sup>1</sup>	0	8	3
E 421	Entr. Analysis of Design	1	3	2
Hu	Humanities	3	0	3
	<b>TOTAL</b>	<b>13</b>	<b>11</b>	<b>17</b>

### Term VIII

		Hrs. Per Wk.		
		Class	Lab	Sem. Cred.
CE 304	Water Resources	3	0	3
EN 375	Environmental Systems	3	3	4
	Elective	3	0	3
CE 424	Engineering Design VIII ‡	0	8	3
Hu	Humanities	3	0	3
	<b>TOTAL</b>	<b>12</b>	<b>11</b>	<b>16</b>

‡ To be selected from the following list: CE 410, CE 519, CE 525, CE 579, CE 595, CE 621 and CM 501 or CM 580.

## 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 typical course sequence for environmental engineering is as follows:

#### Freshman Year

		Term I		
		Hrs. Per Wk.		
		Class	Lab	Sem.
		Cred.		
Ch 107	General Chemistry IA	2	0	2
Ch 117	General Chemistry Lab I	0	3	1
Ma 115	Math Analysis I	3	0	3
PEP 101	Physics I	3	0	3
E 121	Engineering Design I	0	3	2
E 120	Engineering Graphics	0	2	1
E 115	Intro to Programming	1	1.5	2
Hu	Humanities	3	0	3
PE 200	Physical Education	0	2	1
<b>Total</b>		<b>12</b>	<b>11.5</b>	<b>18</b>

		Term II		
		Hrs. Per Wk.		
		Class	Lab	Sem.
		Cred.		
Ch 116	General Chemistry II	3	0	3
Ch 118	General Chemistry Lab II	0	3	1
Ma 116	Math Analysis II	3	0	3
PEP 102	Physics II	3	0	3
E 122	Engineering Design II	0	3	2
E 126	Mechanics of Solids	4	0	4
Hu	Humanities	3	0	3
PE 200	Physical Education II	0	2	1
<b>Total</b>		<b>16</b>	<b>8</b>	<b>20</b>

#### Sophomore Year

		Term III		
		Hrs. Per Wk.		
		Class	Lab	Sem.
		Cred.		
Ma 221	Differential Equations	4	0	4
PEP 201	Physics III	2	0	2

PEP 211	Physics Lab for Engin.	0	3	1
E 234	Thermodynamics	3	0	3
E 245	Circuits and Systems	2	3	3
E 231	Engineering Design III	0	3	2
Hu	Humanities	3	0	3
PE 200	Physical Education III	0	2	1
<b>Total</b>		<b>14</b>	<b>11</b>	<b>19</b>

#### Term IV

		Hrs. Per Wk.		
		Class	Lab	Sem.
		Cred.		
Ma 227	Multivariate Calculus	3	0	3
E 246	Electronics and Instrument	3	0	3
E 232	Engineering Design IV	0	3	2
ChE 210	Process Analysis	4	0	4
EN 375	Environmental Systems	3	3	4
Hu	Humanities	3	0	3
PE 200	Physical Education IV	0	2	1
<b>Total</b>		<b>16</b>	<b>8</b>	<b>20</b>

#### Junior Year

#### Term V

		Hrs. Per Wk.		
		Class	Lab	Sem.
		Cred.		
CE 342	Transport/Fluid Mech	3	3	4
E 344	Materials Processing	3	0	3
E 321	Engineering Design V	0	3	2
E 243	Probability & Statistics	3	0	3
EN 541	Fate & Transport of Contam.	3	0	3
Hu	Humanities	3	0	3
PE 200	Physical Education V	0	2	1
<b>Total</b>		<b>15</b>	<b>8</b>	<b>19</b>

#### Term VI

		Hrs. Per Wk.		
		Class	Lab	Sem.
		Cred.		
EN 345	Modeling & Simulation	3	0	3
E 355	Engineering Economics	3	3	4
E 322	Engineering Design VI	1	3	2
EN 570	Environmental Chemistry	3	0	3
EN 571	Physicochemical Proc.	3	0	3

Hu	Humanities	3	0	3
PE 200	Physical Education VI	0	2	1
<b>Total</b>		<b>16</b>	<b>8</b>	<b>19</b>

### Senior Year

#### Term VII

		Hrs. Per Wk.		
		Class	Lab	Sem.
		Cred.		
EN 573	Biological Processes	3	0	3
EN 575	Environmental Biology	3	0	3
	Elective	3	0	3
E 423	Engineering Design VII	0	8	3
E 421	Entr. Analysis of Design	1	3	2
Hu	Humanities	3	0	3
<b>Total</b>		<b>13</b>	<b>11</b>	<b>17</b>

#### Term VIII

		Hrs. Per Wk.		
		Class	Lab	Sem.
		Cred.		
	Air Pollution Elective <sup>1</sup>	3	0	3
	Soil or Groundwater Elective <sup>2</sup>	3	0	3
	Elective	3	0	3
EN 424	Engineering Design VIII	0	8	3
Hu	Humanities	3	0	3
<b>Total</b>		<b>12</b>	<b>8</b>	<b>15</b>

<sup>1</sup>EN 506 Air Pollution Control or EN 550 Atmospheric Chemistry

<sup>2</sup>EN 561 Soil Chemistry or EN 483 Geotechnical Engineering

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.

### 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 483 Geotechnical Engineering or CE 681 Finite Elements
- CE 484 Concrete Structures or CE 519 Advanced Structures
- CE 486 Structural Steel Design

### **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  
CE 553 Groundwater Engineering  
EN 375 Environmental Systems  
EN 570 Environmental Chemistry

### **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-relating 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."

## **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 (210 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 advance 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.

### **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.

### **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 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 Processes**

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

##### **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

**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 642 Motion of Vessels in Waves

OE 539 Underwater Acoustics

which are in subject areas outside of coastal engineering.

**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 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

### **Environmental Engineering Track**

Program Directors - Professors George Korfiatis and Richard Hires

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

### **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\*).

### **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

### **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 Physiochemical 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

#### **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

#### **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  
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

## **Doctoral Program**

The program leading to the Doctor of Philosophy degree is designed to develop your 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 your scholastic record. A master's degree is required before a student is admitted to the doctoral program. Your 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 time of admission, you must take a qualifying examination that tests your ability to critically analyze the research literature. Upon satisfactory performance in the qualifying examination, and completion of the required course work, you must take an oral preliminary examination. This examination is primarily intended to evaluate your aptitude for advanced research and examine your understanding of the subjects associated specifically with your dissertation topics. Upon satisfactory completion of the preliminary examination and all course work, you will become a doctoral candidate and start your 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, you must defend your 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. You will be assigned an advisor who will help you develop a study plan and who will supervise your 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, you will submit a written report to the departmental committee for approval, and you will be required to take an oral examination on the substance of the design project.

## **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 physiochemical 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.

## **Center for Environmental Systems (CES)**

The Center for Environmental Systems (CES) was created to integrate Stevens' resources in the environmental area. Its mission is to develop and maintain degree, graduate certificate and continuing professional education programs in environmental engineering; conduct basic and applied research in environmental technology development, transfer and implementation; and to foster partnerships with industry, government and environmental service organizations for cooperative approaches to environmental problems. The CES assists industry, government and environmental service organizations by providing research and testing services to develop and apply innovative environmental technologies. With a group of highly-qualified professionals and state-of-the-art laboratory facilities, CES develops engineering solutions to complex environmental problems.

A major component of CES is Stevens Environmental Associates (SEA), which is a partnership between member companies and Stevens. SEA supports continuing education activities (seminars and short courses), which are made available to Stevens students, and assists with research projects. These activities give students a better understanding of the needs of the profession before they graduate by exposing them to typical issues that are not normally covered in an academic setting. The center maintains a research vessel, the R.V. Phoenix, named after the first ocean-going steamboat built by Col. John P. Stevens. The RV Phoenix is a 25-five-foot outboard-powered cabin cruiser equipped for environmental studies in the Hudson estuary and adjacent coastal ocean.

### **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 detector, and atomic absorption spectrophotometer with both graphite furnace and flame capability.

### **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.

## **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, water distribution systems. Prerequisite: E 243.

### **CE 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 the pollutants, reduction and oxidation reactions involving iron, and mass transfer of oxygen; perform literature search; use a spectrophotometer and ion chromatography for phosphate and nitrate analyses; carry out batch experiments to determine 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, Euler and Bernoulli equations, 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-site: 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, 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 differences 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; design and analysis of mechanical, physicochemical and biochemical water and wastewater treatment processes.

**CE 381 Surveying  
(2-3-3)**

Use of surveying instruments; measurement of angles, distances and elevations; field notebook keeping; traverse computations; 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 Engineering Economic Design (E 421) 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, 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, footings.  
Prerequisite: CE 373.

## 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, 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, hydrologic and hydraulic routing. Ground water resources. Planning and management of water resources. Probabilistic methods in water resources, reservoir design, 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 foundation, curved beams, unsymmetric bending, buckling and 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; Flexibility Method, Moment Distribution Method and Slope Deflection Method. Energy methods in structural engineering; virtual work and deformation calculations. Potential energy and its minimization; Rayleigh-Ritz method and introduction to Finite Element method. Arch and cable analysis. Plasticity and Limit State design. Theory of Thin Plates. Introduction to Stiffness analysis of structures. Miscellaneous topics in structural analysis, e.g., plates on elastic foundation. Prerequisite: CE 373 or equivalent.

#### **CE 520 Soil Behavior and its Role in Environmental Applications**

See EN 520 course description.

#### **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 and 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 procedural computer program language (C++, FORTRAN, etc.).

**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**

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 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; 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; 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; application to indeterminate structures, space frames, computer application. Prerequisite: knowledge of computer programming.

**CE 621 Bridge Design for Structural Engineers**

This course will concentrate on the 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, CE 486 or equivalents.

**CE 623 Structural Dynamics**

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

**CE 626 Earthquake Engineering Design**

Introduction to earthquake; its causes and effects; seismology and seismic waves. Design codes (UBC, BOCA, AASHTO). Vibration of structures under ground motion. Dynamics of single- and multi-degree freedom structures under earthquake loading. Response Spectrum method in seismic analysis. Inelastic response of structures. Earthquake-resistant design of building structures; 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, e.g., 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; 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 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 principals 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**

See EN 654 course description.

**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; 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 principle, weighted residual method, Galerkin approximations, continuous and piecewise-defined basis functions, finite-element methods, computer coding of one-dimensional problems, triangular elements - coding of two-dimensional problems, time-dependent problems.

**CE 684 Mixing Processes in Inland and Coastal Waters**

Development of advective-diffusion equations for conservative and non-conservative substances. Fickian diffusion, turbulent diffusion, 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; velocity distribution in open channels. Specific energy, momentum and specific force principles; critical flows; principles of uniform flow and its computation. Gradually varied flow; channel transitions and controls. Rapidly varied flow; hydraulic jump and energy dissipaters. Unsteady flows, waves and wave propagation, flood routing. Applications of numerical methods in hydraulic engineering.

**CE 687 Design of Hydraulic Structures**

Design of small canal and small dam structures including sharp and broad crested weirs, stilling basins, energy dissipaters, spillways, gates, flumes, sluice gates, erosion control structures and transmission pipe lines.

**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 US 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.

**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; settlement analysis, 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

**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 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, 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, 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.

**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, the design deficiency, the 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 class addresses a survey of legal and regulatory approaches to environmental protection. Topics include: environmental ethics, National Environmental Policy Act, state and federal environmental agencies; 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 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

**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 as well as the 1990 update of this regulation requirements 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, physiochemical 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; adsorption and adsorption; combustion; 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; 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 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, 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; 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 siting, 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, 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; 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; 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, effects of air pollution on climate and water; 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; flow nets. Seepage principles, and seepage control measures; Filter and drain design; 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; 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, activated sludge process; aerated lagoons; stabilization ponds; nitrification; denitrification; sludge concentration; aerobic sludge digestion; anaerobic sludge digestion, sludge conditioning; sludge drying, vacuum filtration; 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, 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; Clean Water Act, Safe Drinking Water Act, Superfund, Resource Recovery and Conservation Act, Right-to-Know, Environmental Cleanup Responsibility Act, 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 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, 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 theoretical concepts involved in design and analysis of unit operations and unit processes for environmental pollution control and conservation. Laboratory investigations include mixing, coagulation, flocculation, sedimentation, filtration, vacuum operations, flotation, disinfection, corrosion control, chemical precipitation, adsorption, ion exchange, membrane processes, biological oxidation and anaerobic digestion.

#### **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; numerical methods in groundwater hydraulics. Chemical properties of groundwater, sources and effects of contamination; principles of mathematical modeling of containment transport in groundwater, 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 687 and EN 680 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

### **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; 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; you 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 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; 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, 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, 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 and 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, consideration of structural strength and stiffness. Prerequisite: OE 525 or equivalent.

#### **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; target strength.

#### **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 circulation, 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 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, 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 Coastal 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, Navier-Stokes equation, velocity potential and stream function, Bernoulli's equation, conformal mapping, free surface flows, wave theory, flow in porous media, 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: concentrated and distributed singularities, lift-drag Kutta condition, D'Alembert paradox, Blasius theorem, Karman vortex street. Conformal mapping, Möbius transformation, Schwartz-Christoffel transformation. Applications, added mass and virtual mass, Taylor's added mass theorem, Lagally theorem, Navier-Stokes' equation, exact solutions for parallel flow, Couette flow, Poiseuille flow. Unsteady problems: boundary layer Reynolds number, flat plate boundary layer, Von Karman integral method 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, 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, 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; 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; 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, 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, 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 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, lift, drag, wetted area of hull, appendage drag, propeller effect direct and indirect, spray formation, impact loads in smooth water and waves, porpoising, rough water behavior, tank 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, 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, 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 Burgers equation: nonlinear problems, Newton iteration, 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.

**OE 688 Coastal Ocean Dynamics I\***

Mechanics of rotating flow; inviscid shallow-water theory; topographic Rossby Waves; effects of friction: the Ekman theory; 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 current interest of the faculty and students. Prerequisite: 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