Civil Engineering

Civil engineers apply sophisticated analysis and design techniques to advance the needs of society for shelter, infrastructure, and a safe environment. Graduates pursue not only the traditional fields of structural analysis and design, soil mechanics and foundation design, environmental engineering and policy, or coastal and ocean engineering, but increasingly are taking on important management roles in infrastructure, hazard mitigation and sustainability, and technical roles in the planning, design, and construction of large-scale engineered systems. In addition, a civil engineering degree provides the logical thinking useful in pursuing careers in other professional fields, such as law, business, or medicine.

The Department of Civil Engineering offers programs at the undergraduate, graduate, and postdoctoral levels. Civil Engineering at Hopkins offers a unique balance among mechanics fundamentals, state-of-the-art tools, experimental techniques, and research, with an emphasis on hands-on experimentation as well as integration of computer use into courses as appropriate. A wide range of research opportunities distinguishes the program. Students have participated in projects on structural reliability, earthquake resistance of structures, testing and analysis of historic bridges, and aeroelastic forces on modern long-span cable-supported bridges, to name a few. Two five-year bachelor's/master's degree programs and a five-year cooperative education program are also offered. Graduates of Johns Hopkins University have traditionally risen to leadership roles in education, research, industry, and government.

The Faculty

Annalingam Anandarajah, Professor: geotechnical engineering, constitutive modeling, finite element modeling.

Sanjay R. Arwade, Assistant Professor: structural mechanics, stochastic methods, multi-scale material models.

Robert A. Dalrymple, Professor and Willard and Lillian Hackerman Chair in Civil Engineering: coastal engineering, water wave mechanics, fluid mechanics.

J. Hugh Ellis, Chair and Professor: structural health engineering, environmental systems.

Lori Graham-Brady, Associate Professor: probabilistic mechanics, finite elements, stochastic modeling of materials.

James K. Guest, Assistant Professor: structural analysis and design, material design.

Takeru Igusa, Professor: structural dynamics, earthquake engineering, analysis of uncertainties.

Nicholas P. Jones, Professor in Civil Engineering and Dean of the Whiting School of Engineering: structural dynamics, flow-induced vibration, wind engineering.

Benjamin Schafer, Assistant Professor: structural stability, computational mechanics, experimental methods.

Lian Shen, Assistant Professor: computational fluid dynamics, environmental fluid mechanics, free-surface flows, ocean and coastal engineering.

Joint Appointments

DOGEE is the Department of Geography and Environmental Engineering.

William P. Ball, Professor (DOGEE): environmental engineering.

Edward J. Bouwer, Professor (DOGEE): environmental microbiology, waste treatment.

J. Hugh Ellis, Professor (DOGEE): environmental systems.

Grant Garven, Professor (Earth and Planetary Sciences): groundwater, flow in permeable media.

Charles R. O'Melia, Professor (DOGEE): environmental engineering, aquatic chemistry.

Alan T. Stone, Professor (DOGEE): environmental and aquatic chemistry.

Peter R. Wilcock, Professor (DOGEE): sediment transport, slope stability.

Part-Time and Visiting Appointments

Rameswar Bhattacharyya, Adjunct Professor: marine hydrodynamics, offshore structures.

Jerry DiMaggio, Lecturer: ground improvement methods, soil mechanics.

Patrick Hudson, Lecturer: ocean engineering.

Sanj Malushte, Lecturer: structural analysis and design, dynamics, earthquake structural engineering.

Charles Russo, Lecturer: structural design.

Michael Stello, Lecturer: soil mechanics, foundation design.

Shahin Taavoni, Lecturer: reinforced concrete structures.

Niklas W. Vigener, Lecturer: investigation and evaluation of structures.

Facilities

The teaching and research facilities of the Department of Civil Engineering are located primarily in Latrobe Hall. Additionally, the Coastal Engineering Laboratory is located in the Stieff Building. The department has a library and conference room, and a lounge. Each graduate student is assigned individual study space and a computer.

Teaching laboratories include the undergraduate and graduate soil mechanics laboratories, and the structural testing laboratories. The facilities of the Latrobe shop, including an electro-mechanical technician and a part-time machinist, are available for laboratory courses and research work.

The department sponsors a weekly seminar series, as well as the Richard J. Carroll endowed lectureship. Both are designed to bring prominent civil engineers to campus to speak with students and faculty.

Financial Aid

Undergraduate scholarships and other sources of financial aid have been described earlier (see page 22).

Financial assistance to graduate students is available on a competitive basis in the form of partial or complete tuition remission, teaching assistantships, research assistantships, and fellowships. In addition to university-wide fellowships, graduate students in civil engineering are also eligible for fellowships from the Abel Wolman Graduate Fellowship, the Joseph Meyerhoff Scholarship Fund, the Richard D. Hickman Endowment, the Nancy M. and George Simms Jenkins II Fellowship, and the Hoomes Rich Graduate Fellowship.

Undergraduate Program

Mission Statement:

The civil engineering program educates intellectual leaders of the profession by instilling in them a fundamental understanding of the mathematical principles of physics and nature that underlie engineering science, a practical appreciation of the challenges of creative engineering design, and a sense of responsibility for professional service.

Program Educational Objectives:

Graduates are prepared to be practicing engineers with knowledge and skills needed to:

- Identify, formulate and execute solutions to civil engineering problems using modern engineering tools and principles of science and mathematics.
- Work effectively in a variety of contexts with good communication and teaming skills and with a commitment to professional ethics.
- Understand contemporary issues and the societal and environmental context of civil engineering practice.
- Pursue graduate-level or professional education with a commitment to life-long learning.

The program is accredited by ABET, the Accreditation Board for Engineering and Technology. Considerable flexibility is built into the curriculum so that students may pursue particular interests such as structural or geotechnical analysis and design, environmental and water resource engineering, or economics and systems analysis.

Requirements for the B.S. Degree

(See also General Requirements for Departmental Majors, page 46.)

Requirements for the B.S. degree include 24 credits in humanities, 17 credits in basic sciences, 16 credits in mathematics, and 48 credits in engineering science and design. Electives bring the total to 128 credits, of which at least 6 must be in (W) courses (See Writing Requirement, page 40). Shown below is a typical undergraduate program. This is intended only as a guide. The *Civil Engineering Undergraduate Advising Manual*, which the student can access online, contains more detailed information, including specific requirements and advice with respect to technical and non-technical electives and design credits.

Each student is assigned an adviser, who is to sign all registration forms and add/drop forms. Prior to graduation, all programs are reviewed by the department advising coordinator.

Sample Program:

Freshman Year/Fall

110.108 Calculus I or	
110.109 Calculus II or	
110.202 Calculus III	4
030.101 Intro to Chemistry	3
030.105 Chemistry Lab	1
Humanities/Social Science Elective *or*	3
171.101 Physics I	4
173.111 Physics Lab	1
Total	16

Freshman Year/Spring

110.109 Calculus II or	
110.202 Calculus III or	
110.xxx other math	4
171.102 Physics II	4
173.112 Physics Lab	1
030.104 Organic Chemistry or	4/3
270.220 Dynamic Earth	
500/560.141 Perspectives on the Evolution of Structures	3
Total	15-16

Sophomore Year/Fall

110.202 Calculus III or	
110.xxx other math	4
540.203 Engr Thermodynamics or	
520.213 Circuits	4
560.201 Statics and Mechanics	4
Elective	3
Elective	3
Total	18

Sophomore Year/Spring

550.291 Lin Algebra/Diff Equations	4
560.202 Dynamics	4
560.206 Solid Mechanics and Theory of Structures	4
510.201 Introduction to Engineering Materials	3
Total	15

Junior Year/Fall

560.305 Soil Mechanics	4
570.301 Environmental Engr I: Fundamentals	3
570.351 Intro Fluid Mechanics	3
Technical Elective	3
Elective	3
Total	16

Junior Year/Spring

560.320 Steel Structures	3
570.302 Environmental Engr. II: Water/Wastewater Treatment	3
560.435 Probability/Statistics	3
Nontechnical Elective	3
Elective	3
Total	15

Senior Year/Fall

560.349 Design/Synthesis I	2
Technical Elective	3
Technical Elective	3
Technical Elective	4
Nontechnical Elective	3
Elective	3
Total	18

Senior Year/Spring

560.350 Design/Synthesis II	3
Technical Elective	3
Nontechnical Elective	3
Elective	6
Total	15

Minor in Principles of Structural Engineering

This program is available to non-departmental majors only, who would like an overview of the principles of structural engineering. The following courses are required:

- Core Courses:

  110.108-109 Calculus I, II

  500.141 Perspectives on the Evolution of Structures

  560.201 Statics and Mechanics

  560.206 Solid Mechanics and Theory of Structures
- Seminar (four semesters):
  560.491-494 Civil Engr Seminar
- A two-course sequence in either structures or foundations

The structures sequence consists of two of the following:

560.445 Advanced Structural Analysis
560.320 Steel Structures
560.325 Concrete Structures
560.349-350 Design and Synthesis

The foundations sequence consists of 560.305 Soil Mechanics and one of the following:

560.330 Foundation Design
560.349-350 Design and Synthesis

Bachelor's/Master's Honors Programs

The Department of Civil Engineering has two honors programs for the combined bachelor's/master's degrees. Formal application is required, whereupon students may be admitted as early as the second semester of the sophomore year. The honors programs take five or six years, depending on the options selected, and carry an automatic tuition waiver of 50 percent after the first eight semesters of undergraduate work.

One program combines a B.S. in Civil Engineering with either a master of science in engineering in Civil Engineering (M.S.E.) or a master of civil engineering (M.C.E.). The other program leads directly from the B.S. in Civil Engineering to the M.S.E. in Environmental Engineering through the Department of Geography and Environmental Engineering.

Graduate Programs

The Department of Civil Engineering offers a graduate program that is based primarily in structural engineering/structural mechanics, geotechnical engineering/geomechanics, probabilistic methods/hazards management, and coastal/ocean engineering. To be admitted to the program, students are expected to have graduated with an outstanding record in an appropriate undergraduate program.

Civil engineering today is a dynamic, complex, and technologically sophisticated field. Powerful computational methods and high-strength materials have offered new opportunities and new challenges. The graduate program is designed to instill in the student the fundamental theoretical concepts of mechanics as well as practical knowledge of modern structural and geotechnical engineering.

Requirements for the M.S.E. Degree

Obtaining the master of science in engineering degree in Civil Engineering normally takes three to four semesters of full-time study. It is also possible to satisfy the requirements on a part-time basis. The option for those receiving a terminal M.S.E. degree consists of a minimum of eight courses and a master's thesis. The option for those going on to the Ph.D. consists of 10 courses and passing the department qualifying examination and the Graduate Board oral examination. Transfer credit for work completed at another institution is generally not counted toward the M.S.E. degree.

There is no set curriculum for graduate study. Students are expected to design a program that offers them depth in structural engineering/structural mechanics, geotechnical engineering/geomechanics, or probabilistic methods/hazards management as well as a degree of breadth in related disciplines. All programs must be approved by the department.

Requirements for the M.C.E. Degree

The master of civil engineering degree requires 10 courses. No more than one grade of C may be counted toward this degree. Oriented toward professional practice, this degree program is not normally selected by those students planning to go on for the Ph.D. Courses are scheduled so that it is possible to earn the M.C.E. degree on a part-time basis, taking all courses in the late afternoon and evening. Students normally take some courses listed in this catalog and some listed in the catalog for Part-Time Programs in Engineering and Applied Science. Information regarding this program, including admission, is available from the Office of Part-Time Programs in Engineering and Applied Science.

Requirements for the Ph.D. Degree

The Ph.D. in Civil Engineering degree requires a minimum approved program of 14 technical courses (or their equivalent) beyond the bachelor's degree. All doctoral candidates are expected to demonstrate a high level of oral and written proficiency in English. Candidates must pass a department qualifying examination of their general scientific preparation, submit for approval a detailed preliminary proposal for the dissertation, and pass a Graduate Board oral examination. The Ph.D. degree is awarded following a successful defense of the doctoral dissertation. Appropriate graduate courses taken at another institution may be used toward the Ph.D. degree. Credit transfers are determined on a case-by-case basis.

Postdoctoral Program

The Johns Hopkins University traditionally has a number of postdoctoral fellows. Fellows conduct research under the sponsorship of one or more faculty members in the department.

Undergraduate Courses

500/560.141 (E,N,Q,W) Perspectives on the Evolution of Structures
Why do buildings and bridges look the way they do today? Students will be provided the tools to answer this question for themselves through a study of the history of the design of buildings and bridges throughout the world from both the engineering and architectural/aesthetic perspectives. Only simple mathematics is required (no calculus). Students will participate in individual and group critique of structures from engineering, architectural, and social points of view.
Arwade, Schafer 3 credits

560.201 (E,N) Statics and Mechanics of Materials
Basic principles of classical mechanics applied to the equilibrium of particles and rigid bodies at rest, under the influence of various force systems. In addition, the following topics are studied: free body concept, analysis of simple structures, friction, centroids and centers of gravity, and moments of inertia. Includes laboratory experience. No freshmen without permission of instructor.
Staff 4 credits

560.202 (E,N) Dynamics
Basic principles of classical mechanics applied to the motion of particles, system of particles and rigid bodies. Kinematics: analytical description of motion; rectilinear and curvilinear motions of particles; rigid body motion. Kinetics: force, mass, and acceleration; energy and momentum principles. Introduction to vibration. Includes laboratory experience. Prerequisites: 560.201, 110.109 Calculus II, 171.101 General Physics I.
Dalrymple 4 credits

560.206 (E,N) Solid Mechanics and Theory of Structures
Application of the principles of structural analysis for statically determinant and indeterminant structures (trusses, cables, beams, arches, and frameworks). Calculation of internal forces and stresses in members and structures. Determination of deflections by equilibrium and energy methods. Analysis of indeterminate structures by flexibility and stiffness solutions. Prerequisite: 560.201
Staff 4 credits

560.305 (E) Soil Mechanics
Basic principles of soil mechanics. Classification of soils. Compaction theory. Consolidation, seepage and settlement analysis. Stress-strain and shear strength of soils. Introduction to earth pressure theories and slope stability analyses. Laboratory is included. Prerequisite: 560.206. Co-requisite: 570.351 Fluid Mechanics.
Anandarajah 4 credits

560.320 (E) Steel Structures
Principles, analysis, and methodologies for conceptual and detailed design of steel structures. Emphasis on the role of mechanics in modern structural engineering design specifications with a focus on load and resistance factor design. Topics include behavior and design of hot-rolled and cold-formed steel: connections, members, frames, and advanced analysis techniques.
Schafer 3 credits

560.325 (E) Concrete Structures
Principles of behavior of reinforced concrete beams, columns and slabs, with application to the design of elementary structures are introduced. The ultimate strength and the elastic methods of analysis are used. Prerequisite: 560.206.
Staff 3 credits

560.330 (E) Foundation Design
Application of soil mechanics theory and soil test results to the analysis and design of foundations for structures; retaining walls; embankments; design of pile, and shallow footing foundations; slope stability. Prerequisite: 560.305.
Anandarajah 3 credits

560.349 (E) Design and Synthesis I
A study of the engineering design process from problem definition to the final design. There are team projects which include written and oral presentations. Prerequisite: senior in Civil Engineering.
Russo, Vigener 2 credits

560.350 (E) Design and Synthesis II
Seniors are organized into a consulting engineering firm to prepare the design of a research building for a state university. Students execute the design process from conceptual design through the preparation of drawings and specifications. Facets of the design process include building technology, structural engineering, geotechnical engineering, green design in accordance with USGBC LEED guidelines, and project budgeting and scheduling. The student firm prepares a final design submittal and makes a formal presentation.
Russo, Vigener 3 credits

560.380 (E) Introduction to Ocean Science and Engineering
Fundamentals of oceanography, marine hydrodynamics, and flow-structure interactions. Topics include sea environment, water waves, transport processes, measurement techniques, ship hydrodynamics, naval architecture, and wave loads on offshore structures and structure responses. Prerequisite: Introductory Fluid Mechanics
Shen 3 credits

560.435 (E,Q) Probability and Statistics in Civil Engineering
Development and applications of the analysis of uncertainty, including basic probability, statistics and decision theory, in civil engineering areas of soil mechanics, structures, transportation and water resources. Prerequisite: 110.109 Calculus II.
Igusa 3 credits

560.445 (E) Advanced Structural Analysis
Matrix methods for the analysis of statically indeterminate framed structures such as beams, plane trusses, space trusses, plane frames, grids and space frames. Stiffness and ßexibility methods. Prerequisite: 560.206.
Arwade 3 credits

560.475 (E) Advanced Soil Mechanics
Difference between soils and other materials, stresses in soils due to structural foundations, elastic, consolidation and secondary consolidation settlements of footings, shear strength and stress-strain behavior of clays and sands, approximate nonlinear elastic, Mohr-Coulomb, Ramberg-Osgood, and Hyperbolic stress-strain models for soils, nonlinear Winkler foundation analysis of piles, pile groups, and drilled shafts due to vertical and horizontal loads, foundation spring constants for superstructure analysis. Prerequisite: 560.305.
Anandarajah 3 credits

560.491-494 (E) Civil Engineering Seminar
Seminar series of speakers on various aspects of civil engineering. Juniors and seniors in Civil Engineering are expected to enroll in this sequence; juniors and seniors receive one-half credit. Different speakers are invited each semester.
Staff 5 credit

560.525-526 Independent Study in Civil Engineering
Prerequisite: permission of instructor.
Staff 1-3 credits

Undergraduate Courses
(Part-Time)

565.108 Construction Management and Economics
This course examines the principles of operations management in the construction industry. Topics include office and field organizations, the functions of each on a construction project, and principles of estimating, scheduling, and cost controls.
Staff 3 credits

565.430 Structural Design with Timber, Masonry, and Other Materials
This course offers a review of the current requirements and techniques for the design of modern structures using materials such as engineered brick and concrete masonry, timber, aluminum, and plastics. Relevant design specifications and criteria are included. Prerequisite: 565.105 Theory of Structures I or 560.206 (E,N) Solid Mechanics and Theory of Structures. In addition, one previous design course is preferred.
Staff 3 credits

Cross-Listed

500.141 (N,Q,E,W) Perspectives on the Evolution of Structures
Arwade, Schafer 3 credits

570.302 (N,E) Environmental Engineering II: Water and Wastewater Treatment
Ball 3 credits

570.305 (N,E) Environmental Engineering Systems Design
Ellis 4 credits

570.351 (E) Introduction to Fluid Mechanics
Staff 3 credits

570.429 (E,N) Surface Effects in Technological Processes and Materials
Shchukin 3 credits fall

Graduate Courses

560.691-692 Graduate Seminar
Graduate students are expected to register for this course each semester. Both internal and outside speakers are included.
Staff

560.728: Stochastic Micromechanics
The course builds on the knowledge gained in classes on structural mechanics and solid mechanics, extending the concepts of those classes in two directions, (1) the inclusion of uncertainty in problems in mechanics and (2) consideration of mechanics phenomena which occur at small scales.
Arwade 3 hours

560.729 Structural Mechanics
(Formerly 560.455)
Basics of the theory of elasticity for engineers. Stress, strain and constitutive laws. Stress finction solutions. Plane stress, plane strain, and axisymmetric problems. Work and energy methods. Beams on elastic foundations.
Graham-Brady 3 hours fall

560.730 Finite Element Methods
The basic concepts of the FEM are presented for one-, two-, and three-dimensional boundary value problems (BVPs). Problems from heat conduction and solid mechanics are addressed. The key topics include relationships between strong, weak, and variational statements of BVPs, weighted residual methods with an emphasis on the Galerkin method, specialization of Galerkin approximations of weak statements and Ritz approximations of variational statements to obtain finite element formulations, specific element formulations, convergence properties, solutions of linear systems of equations, and time-dependent problems.
Graham-Brady 3 hours fall

560.732 Numerical Methods in Geomechanics
Finite element modeling of geomechanics problems including seepage problems, elastic and plastic solid mechanics problems, and earthquake engineering problems. Fundamentals of hardening plasticity and advanced soil constitutive models. Applications of finite element method to the analysis of slopes, seepage through soils, sheet-pile walls, piles, earthquake liquefaction problems, and earthquake soil-structure interaction problems. Prerequisite: background in finite element analysis or permission of instructor.
Anandarajah 3 hours

560.733 Computational Plasticity
Material plasticity analyzed through computational techniques are discussed in this course. Topics include plasticity, viscoplasticity, integration algorithms, variational formulation and finite element methods, nonlinear continuum mechanics.
Graham-Brady 3 hours spring

560.734 Advanced Probability and Statistics for Engineers
Material covers multi-variate distributions, transformations of random variables, point processes, reliability, Bayesian techniques, parameter estimation, inference and decision theory. Prerequisite: 560.435 or other introductory course in probability and statistics.
Igusa 3 hours fall

560.736 Uncertain Systems: Prediction and Decision Analysis
Computational techniques for solving problems in stochastic mechanics: perturbation and averaging techniques, discrete representation of stochastic processes, Hilbert space techniques for stochastic operators, topics in the stochastic finite element method, signal analysis, simulation techniques. Prerequisites: 560.730, 560.731, or equivalent.
Staff 3 hours spring

560.740 Representations of Uncertainty for Engineering Models
Introduction to general tools in the interface between uncertain parameters and models and the analysis and design of engineered systems. Possible topics, chosen according to student interest: Bayesian nets, geostatistics, response surfaces, principal components analysis, decision-based design theory, nonprobabilistic methods.
Igusa 3 hours spring

560.741 Theoretical and Computational Plasticity
Course discusses the principles behind elastoplastic and viscoplastic constitutive laws for engineering materials, sample constitutive models, explicit and implicit integration algorithms, and finite element implementation of plasticity models. Prerequisite: Knowledge in continuum mechanics or instructors permission
Anandarajah 3 hours

560.745 Retaining Structures and Slope Stability
Earth pressure theories. Design and behavior of rigid, flexible, braced, tied-back, slurry, and reinforced soil structures. Stability of excavation, cut, and natural slopes. Methods of slope stability analysis, effects of water forces, shear strength selection for analysis. Stability and seepage in embankment dams. Prerequisite: 560.305 or equivalent.
Staff 3 hours

560.750 Soil Dynamics
Study of soil behavior under dynamic loading conditions: wave propagation and attenuation, field and laboratory techniques for determining dynamic soil properties and cyclic strength, cyclic stress-strain behavior of soils, liquefaction and evaluation of liquefaction susceptibility, nondestructive evaluation of foundation systems, foundation design for vibratory loadings. Prerequisite: 560.305 or equivalent.
Staff 3 hours

560.752 Structural Dynamics
Functional and computational examination of elastic and inelastic single degree of freedom systems with classical and non-classical damping subject to various input excitations including earthquakes with emphasis on the study of system response. Extension to multi-degree of freedom systems with emphasis on modal analysis and numerical methods. Use of the principles of structural dynamics in earthquake response and the design of multistory buildings.
Schafer 3 hours

560.754 Wind Engineering
Climatology and meteorology of the Earth's boundary layer. Basic aerodynamics, structural dynamics, and principles of stochastic loadings applicable to the wind engineering of structures. Wind tunnel modeling of buildings and bridges. Aeroelastic and other special problems. Corequisite: 560.752.
Staff 3 hours

560.756 Earthquake Engineering
Plate tectonics and seismicity of the Earth. Engineering seismology-quantification and classification of earthquake ground motions. Dynamics of structures subjected to earthquake loads. Design spectra. Building code provisions. Design concepts and detailing. Soil-structure interaction. Response of special structures. Corequisite: 560.752.
Staff 3 hours

560.757 Random Fields
Stochastic field theory, as applied to 1-, 2-, and n-dimensional random processes. Descriptors of homogeneous and non-homogeneous random fields. Study of load average processes. Review of various other topics in random field theory and application.
Graham-Brady 3 hours

560.758 Random Vibration
Random process theory. Modeling of stationary and nonstationary excitations, and prediction of response of single- and multi-degree-of-freedom systems and continuous systems. Prerequisite: 560.752 or equivalent.
Igusa 3 hours

560.760 Structural Stability
Concepts of stability of equilibrium; stability criteria. Work, energy and variational methods. Elastic buckling of columns, beams, frames, and plates. Introduction to inelastic and dynamic buckling. Prerequisite: 560.445 or equivalent.
Schafer 3 hours

560.770 Fundamentals of Soil Behavior
Microstructural aspects of geotechnical behavior of clays and sands. Influence of structure, fabric, and compositional variables on geotechnical properties of soils. Fundamentals of overconsolidation, cohesion, friction, and sensitivity. Laboratory stress-strain and shear strength behavior of clays and sands. Critical state theory for clays. Factors influencing permeability of soils. Anisotropy and geotechnical properties of soils. Influence of pollutants on mechanical properties of clays. Prerequisite: 560.305.
Anandarajah 3 hours

560.780 Coastal Engineering
Coastal processes and their influence on engineering at the shoreline. Waves and currents, equilibrium beach profiles, littoral transport, shoreline modeling and the behavior of tidal inlets. The impact of structures on the shoreline.
Dalrymple 3 hours

560.781 Introduction to Water Wave Mechanics
The theories governing water waves are discussed. Linear waves will be explored in detail. Aspects of nonlinear waves will be presented.
Dalrymple 3 hours fall

560.782 Hydrodynamics
Fundamentals of fluid mechanics in the context of ocean science and engineering, naval architecture, and coastal processes, at engineering scales. Topics include fluids transport, conservation principles, free-surface boundary conditions, vorticity and Kelvin's theorem, elementary potential flows, method of conformal mapping, lift due to circulation, Green's theorem, hydrodynamics forces, added mass, ship and ocean waves, wave force on offshore structures, elementary viscous flows, laminar and turbulent boundary layers, flow past bluff bodies, forces of ocean flows on stationary and floating bodies, similitude and scaling laws, and model testing.
Shen 3 hours fall

560.783 Ocean Vehicles
Hydrodynamics with applications in surface ships, coastal and offshore structures, and aquatic animal propulsion. Waves, winds and currents in sea environment. Interactions between surface waves and floating bodies. Sea loads on offshore structures. Ship hydrodynamics and seakeeping. Fish swimming mechanism and biomimetics.
Shen 3 hours spring

560.785 Coastal and Ocean Modeling
Course discusses the numerical and physical modeling techniques used in coastal and ocean engineering, including finite difference, finite and boundary element methods, and particle methods. Some aspects of parallel computing will be included.
Dalrymple 3 hours spring

560.786 Structural Reliability
Reliability theory and its application to problems in civil engineering (primarily structural) design and analysis. The course will include some review of probability theory, statistics and the theory of stochastic processes/fields, second moment methods along with first and second order reliability approaches. Probabilistic modeling of loads is considered. Component-wise measures of reliability are investigated as a gateway to the theory, but estimation of structural system reliability is the overall objective of the class. The relationship of the theory of reliability to structural design codes is discussed.
Arwade 3 hours spring

560.835-836 Graduate Research in Civil Engineering
Prerequisite: permission of instructor.
Staff

Graduate Courses
(Part-Time)

565.421 Fatigue and Fracture in Steel Bridges
The course is specially designed for practicing engineers or graduate students involved in fatigue design/evaluation of steel bridges. It introduces the concept of stress intensity factor in fracture mechanics for members with cracks, where the theories of strength of materials do not apply. It also discusses the theories and mechanisms of fatigue and fracture behavior of various structural details such as welded, bolted, and riveted. In addition, the course provides in-depth explanations on the theoretical background, historical development, and practical applications of the current AASHTO specifications on fatigue design/evaluation of steel bridges. Understanding certain concepts and theories of fracture mechanics is crucial for engineers who are responsible for fatigue design/evaluation of steel bridges. This course should significantly enhance the knowledge and quality of work of the students in this field.
Staff 3 hours

565.490 Bridge Design Project
This course provides a hands-on experience for learning bridge design using the AASHTO specifications. Under the guidance of the instructor, the students work as a team for the design of a real-life bridge in the Baltimore area. All engineering issues required in a bridge design

project will be addressed at different levels, including environmental impact, aesthetics, geometry and layout, superstructure, substructure, constructibility, cost estimates, plans and specifications. Class time consists of lecture and project work.
Staff 3 hours

565.605 Advanced Reinforced Concrete Design
This intensive course covers reinforced concrete materials and specifications and includes the following topics: conception, analysis, and design of continuous beams and frames; building; bridges and shells; elements theory, with emphasis on the ultimate strength method; precast and prestressed concrete; and special topics. Prerequisite: 565.126 Structural Design II or 560.325 Concrete Structures.
Staff 3 hours

565.620 Advanced Steel Design
This course examines advanced designs of structural steel building, including consideration of hot-rolled and cold-formed steel shapes and overall concepts of the structural system. Prerequisite: 565.125 Structural Design I or 560.320 Steel Structures.
Staff 3 hours

565.625 Advanced Foundation Design
This course covers performance requirements and review of soil mechanics; laboratory testing, subsurface investigation and in situ testing; bearing capacity and settlements of shallow foundations; design of spread footings and mat foundations; axial capacity of deep foundations; settlements of deep foundations; lateral capacity of deep foundations; weak, compressible, and expansible soils; earth pressure theories; cantilever and sheet-pile retaining structures. Prerequisites: 560.330 Foundation Design and 560.475 Advanced Soil Mechanics.
Staff 3 hours

565.630 Prestressed Concrete Design
Topics for discussion include prestressed concrete materials, prestressing systems, and loss of prestress; analysis and design of sections for ßexure, shear, torsion, and compression; consideration of partial prestress, composite sections, and slabs. Prerequisite: 560.325.
Staff 3 hours

565.635 Ground Improvement Methods
The course addresses the selection cost, design, construction, and monitoring of ground improvement methods for problematic soils and rock. Ground improvement methods covered include wick drains, micropiles, light-weight fill materials, soil nailing, mechanically stabilized slopes and walls, grouting, stone columns, dynamic compaction, and soil mixing. Prerequisites: 560.330, 560.475.
Staff 3 hours

565.645 Marine Geotechnical Engineering
This course introduces students to soil mechanics in the marine environment. Topics covered include the nature of marine sediments, soil behavior due to cyclic loading, marine geotechnical investigations, shallow foundations and dead-weight anchors, pile foundations and anchors, penetration and breakout of objects on the seafloor, marine slope stability, soft ground improvement, marine dredging, and project planning. Prerequisite: 565.121 Soil Mechanics or 560.305 Soil Mechanics.
Staff 3 hours Offered during the summer in odd years

565.650 Port and Harbor Engineering
Planning and engineering of ports and harbors has received renewed worldwide interest as the newest super-large cargo ships push the envelope for channel depth and berth space. This course covers planning of marine terminals and small-craft harbors, ship berthing and maneuvering considerations, port navigation, marine structures, inland navigation, marine construction planning, sediment management, and port economics. A field trip to the Port of Baltimore provides practical application of course material and shows students firsthand the unique challenges of engineering on the waterfront.
Staff 3 hours Offered during the summer in even years

565.655 Hydromechanics of Floating Structures-Platforms and Ships
Course topics include resistance of floating structures, sea keeping of free-floating and moored structures; and maneuverability and control (including course keeping, hydrodynamic coefficients, and control surfaces).
Staff 3 hours

565.660 Computer Methods for Design of Offshore Structures
Course topics include design methodology, computational methods, conceptual design, preliminary design calculations, and computer graphics; mathematical techniques, parametric studies, and optimization techniques; and design applications to fixed, floating, and moored structures, including structural integrity, stability, and seakeeping.
Staff 3 hours

565.665 Ocean Engineering Mechanics
Students examine linear, nonlinear, and random theories of wave mechanics; wave-induced loadings on fixed structures; wave-structure-soil interactions in both deterministic and random seas; wave-induced motions of floating structures; and sea floor mechanics. Although the course stresses analytical methods, experimental techniques will be introduced where appropriate.
Staff 3 hours Offered occasionally during the fall

565.670 Coastal Structures
Over half of the US population lives in coastal areas, and this percentage has been steadily increasing. Civil engineering of structures at the coastline is important to infrastructure development and community protection. This course covers the practical design and analysis of coastal structures such as seawalls, breakwaters, groins, and jetties. Topics include wave forces, sediment transport, and

coastal zone planning. Prerequisite: 560.780 Coastal Engineering or 560.781 Introduction to Water Waves
Staff 3 hours Offered during the spring in even years

565.675 Hydrodynamics of Estuaries
The Chesapeake Bay is the largest of the nation's 130 estuaries, covering over 4,000 square miles with over 11,000 miles of shoreline. This course provides a general introduction to estuary dynamics, including tides, shallow water waves, dispersion, sedimentation, salinity stratification and mixing, pollution, and flushing. Concepts are specifically applied to the Chesapeake Bay, including a field trip on the Bay in late Spring to make field measurements. Prerequisite: 535.119 Fluid Mechanics or equivalent.
Staff 3 hours Offered during the spring in odd years