

Department of Civil and Environmental Engineering

Chairperson:	Sadek, Salah
Professors:	Ayoub, George; Basha, Habib; El-Fadel, Mutasem; Hamad, Bilal; Harajli, Mohamed; Kaysi, Isam; Mabsout, Mounir; Sadek, Salah
Professors Emeriti:	Abboud-Klink, Sami; Iliya, Raja
Associate Professor:	Inglessis, Constantine
Assistant Professors:	Abou Zeid, Maya; Assaf, Hamed; Chehab, Ghassan; El-Khoury, Hiam; Najjar, Shadi; Saad, George; Saikaly, Pascal
Senior Lecturer:	Azar, Kamal
Lecturers:	El Khatib, Helmi; El Khatib, Ibrahim; Fawwaz, Youssef; Hatem-Musallem, Manal; Karnib, Ali; Kasti, Fuad; Nader, Halim; Nasreddine, Khaldoun; Sadeck, Salah El-Dinn; Semerjian, Lucy
Instructors:	El Jam, Farah; Haroun, Akram; Hasbini, Hayssam; Huijjer, Carla; Kassab, Maya; Nehme, Elias; Saleh, Maha

Undergraduate Programs

The Department of Civil and Environmental Engineering (CEE) offers the degrees of Bachelor of Engineering (BE): major, Civil Engineering (CE); and Bachelor of Science (BS): major, Construction Engineering (ConsE).

The mission of the undergraduate programs of the CEE department is to provide a stimulating and supportive environment for high-standard education; to prepare graduates for a lifelong productive career in addressing problems in a rapidly-changing world, while instilling in them an appreciation of leadership qualities, professionalism, and ethics; to provide professional services of the highest quality to the community; and to contribute to expanding the knowledge and technological base in civil and environmental engineering.

Bachelor of Engineering (BE), Specialization: Civil Engineering (CE)

Program Educational Objectives

The objectives of the CE program are to see our graduates move on to become:

- Engineers who hold central positions in various sub-disciplines of civil engineering in local, regional, and international practice.
- Graduates who are admitted and successfully completing advanced degrees in leading universities around the world.
- Leaders in their profession and in the service of their community.

Curriculum

Term I (Fall)			Credits
CIVE	200	Introduction to Civil Engineering	2
EECE	230	Introduction to Programming	3
MATH	201	Calculus and Analytical Geometry III	3
PHYS	210	Introductory Physics II	3
PHYS	210L	Introductory Physics Laboratory II	1
Arabic Elective			3
			Total 15
Term II (Spring)			Credits
CIVE	210	Statics	3
EECE	210	Electric Circuits	3
MECH	220	Engineering Graphics	1
MATH	202	Differential Equations	3
ENGL	206	Technical English	3
Ethics Elective (An Approved General Education Humanities Course)			3
			Total 16
Term III (Summer)			Credits
CIVE	360	Surveying	2
STAT	230	Introduction to Probability and Random Variables	3
Humanities Elective			3
			Total 8

Term IV (Fall)			Credits
CIVE	310	Mechanics of Materials	3
CIVE	320	Construction Materials and Technologies	2
CIVE	350	Environmental Engineering	3
CIVE	370	Introduction to Information Technology	3
MATH	251	Numerical Computing	3
Humanities Elective			3
			Total 17
Term V (Spring)			Credits
CIVE	311	Structures I	3
CIVE	340	Fluid Mechanics and Laboratory	3
CHEM	202	Introduction to Environmental Chemistry	3
CHEM	203	Introductory Chemical Techniques	2
Biology Elective or			
CIVE	351	Environmental Microbiology	3
Humanities Elective			3
			Total 17
Term VI (Summer)			Credits
CIVE	430	Engineering Geology	3
ENMG	400	Engineering Economy	3
English Elective			3
			Total 9
Term VII (Fall)			Credits
CIVE	410	Structures II	3
CIVE	420	Concrete I	3
CIVE	440	Hydraulics and Laboratory	3
CIVE	460	Highway Engineering	3
Math Elective (MATH 212, MATH 218, MATH 281, or an approved math course)			3
			Total 15
Term VIII (Spring)			Credits
CIVE	421	Concrete II	3
CIVE	431	Soil Mechanics and Laboratory	3
CIVE	441	Engineering Hydrology	3
CIVE	450	Water and Wastewater Treatment and Laboratory	3
CIVE	461	Transportation Engineering and Laboratory	3
			Total 15

Term IX (Summer)			Credit
CIVE	500	Approved Experience	1b.
Term X (Fall)			Credits
CIVE	501	Final Year Project I	1
CIVE	530	Foundation Engineering	3
CIVE	580	Construction Management	3
Technical Elective I			3
Technical Elective II			3
Social Science Elective			3
			Total 16
Term XI (Spring)			Credits
CIVE	502	Final Year Project II	3
Technical Elective III			3
Technical Elective IV			3
Economics Elective			3
Social Science Elective			3
			Total 15
			Total = 143 credit hours

Technical Electives of Term X and Term XI

- CIVE 503 Special Topics in Civil and Environmental Engineering
- Undergraduate (500 series) or graduate (600 series) courses in Civil and Environmental Engineering
- Approved courses from other departments

Bachelor of Science (BS), Specialization: Construction Engineering (ConsE)

Program Educational Objectives

The program is based on a set of educational objectives that fall under the following themes:

Civil Engineering – Fundamentals and Design

- To impart a sound understanding of the fundamental principles and concepts of civil engineering.
- To impart the knowledge of basic and applied engineering design used in the construction industry, and in the specialty field of construction engineering.

Construction Engineering – Basic Skills, Principles, and Technologies

- To help students develop the engineering principles and the mathematical, scientific, and computational skills required to formulate and solve construction engineering problems which include construction planning, processes, methods, materials, equipment, safety, and cost.
- To encourage independent thinking and the use of novel technologies in order to propose creative solutions and meet technical challenges.

Construction Engineering - Professional and Business Context

- To prepare students for leading roles in the profession and the community by promoting issues of professional and ethical conduct.
- To impart an understanding of management concerns in construction such as economics, business, statistics, leadership, and decision methods.
- To instill in students the interpersonal, teamwork and communication skills necessary to perform professionally and make sound decisions in conditions of risk and uncertainty.

Contemporary Issues and Social Context

- To equip students with the ability to use modern experimental and computational tools in the design and evaluation of the economic, environmental, and social impact of construction engineering solutions.
- To develop in students the ability to integrate construction engineering fundamentals with contemporary applications and issues facing the construction industry.

Curriculum

Term I (Fall)			Credit Hours
CIVE	200	Introduction to Civil Engineering	2
CIVE	210	Statics	3
PHYS	210	Introductory Physics II	3
PHYS	210L	Introductory Physics Laboratory II	1
MATH	201	Calculus and Analytical Geometry III	3
ENGL	203	Academic English	3
			Total 15

Term II (Spring)			
CIVE	310	Mechanics of Materials	3
CIVE	220	Construction Drawing	2
EECE	210	Electric Circuits	3
CIVE	371	Introduction to Information Technology	3
ARAB	2nn	Arabic Elective	3
	2nn	Humanities Elective	3
			Total 15

Term III (Summer)			
CIVE	361	Surveying for Construction Engineering	3
STAT	230	Introduction to Probability and Random Variables	3
ENGL	206	Technical English	3
			Total 9

Term IV (Fall)			
CIVE	311	Structures I	3
CIVE	321	Construction Materials and Quality Control	3
CIVE	340	Fluid Mechanics and Laboratory	3
CHEM	202	Introduction to Environmental Chemistry	3
CHEM	203	Introduction Chemical Techniques	2
	2nn	Math/ Science Elective	3
			Total 17

Term V (Spring)			
CIVE	350	Environmental Engineering	3
CIVE	420	Concrete I	3
CIVE	480	Construction Management	3
CIVE	481	Construction Methods and Safety	3
CIVE	460	Highway Engineering	3
		Social Science Elective	3
			Total 18

Term VI (Summer)			
CIVE	482	Supervised Internship	1
			Total 1
Term VII (Fall)			
CIVE	431	Soil Mechanics and Laboratory	3
	2nn	Humanities Elective	3
CIVE	483	Construction Systems Integration	3
CIVE	nnn	Free Construction Engineering Elective	3
ECON	212	Elementary Macroeconomic Theory	3
			Total 18
Term VIII (Spring)			
	2nn	MATH/Science Elective	3
CIVE	440	Hydraulics and Laboratory	3
CIVE	483	Project Planning, Scheduling and Control	3
CIVE	nnn	Free Construction Engineering/CEE Elective	3
	2nn	Humanities Elective	3
			Total 15
Total = 110 credit hours			

Course Descriptions

CIVE 200 Introduction to Civil Engineering 2 cr.

The course will include a limited number of lectures and will rely on hands-on laboratory experiments and projects to introduce basic concepts and skills. Through lectures, discussions and projects, the students will be exposed to the different fields of Civil Engineering, such as environmental, hydraulic, geotechnical, structural and transportation engineering.

CIVE 220 Construction Drawing 2 cr.

An introductory course on 2-D drawing, orthogonal projection, auxiliary views, sectioning and sectional views, dimensioning and tolerance schemes, and standard layouts. Introduction to use of CAD in civil and construction engineering. Interpretation of typical civil engineering drawings. Using CAD to generate plans, cross section and profile drawings, and detail drawings.

CIVE 210 Statics 3 cr.

A course outlining vector mechanics of forces and moments; free-body diagrams; equilibrium of particles and rigid bodies in two and three dimensions; plane and space trusses; frames and machines; axial, shear, and moment diagrams of beams and simple frames; friction; center of gravity and centroid; area moment of inertia; computer applications. *Pre- or co-requisite: MATH 201.*

CIVE 310 Mechanics of Materials 3 cr.

A course on stresses, strains, and stress-strain relationships; temperature; axial bars in tension and compression; torsion of circular bars; bending and shear stresses in beams; combined stresses; stress transformation and Mohr's circle; and computer spreadsheet *Prerequisite: CIVE 210.*

- CIVE 311 Structures I 3 cr.**
An introductory course covering equilibrium, stability, and determinacy; influence lines for beams and trusses; deflection of beams and frames by double-integration method, moment-area theorems, and conjugate beam; introduction to indeterminate structures; approximate analysis of indeterminate building frames; computer structural analysis applications; project building modeling and assessment *Prerequisite: CIVE 310.*
- CIVE 320 Construction Materials and Technologies 2 cr.**
Introduction to the composition and properties of engineering materials such as asphalt, cement, concrete, geological materials, steel, polymers, and wood. Hands on laboratory experiments and demonstrations are part of the course, and are designed to familiarize the student with the materials, testing methods, equipments, and standards.
- CIVE 321 Construction Materials and Quality Control 3cr.**
A course that covers materials used in construction; physical and mechanical properties of construction materials such as asphalt, pavement base materials, Portland cement concrete, steel, polymers, wood, aluminum, and advanced composite materials; proportioning of concrete mixtures including admixtures; and hands on laboratory experiments and demonstrations to familiarize students with testing methods, equipment, standards, and quality control procedures.
- CIVE 340 Fluid Mechanics and Laboratory 3 cr.**
A course that deals with fluid properties, fluid static, continuity equation, Bernoulli's equation, energy principle, momentum principle, laboratory experiments.
- CIVE 350 Environmental Engineering 3 cr.**
A course that introduces the fundamentals of environmental engineering. A screening course of major topics in environmental engineering including water and wastewater, environmental hydrology, environmental hydraulics and pneumatics, air, solid waste, environmental modeling, and hazardous waste.
- CIVE 351 Environmental Microbiology 3 cr.**
A course that introduces the basic principles of environmental microbiology and discusses example applications from the natural and engineered worlds. The main goals of this course are to present an overview of important micro-organisms involved in environmental systems, their ecology, their interactions with various pollutants, and their beneficial or harmful effects on humans.
- CIVE 360 Surveying 2 cr.**
A course on the theory of measurements and errors; linear measurements; surveying instruments; leveling; angles, bearings, and azimuths; stadia measurements; traversing-field aspects; traverse computations and adjustment; topographic surveying; triangulation.
- CIVE 361 Surveying for Construction Engineering 3cr.**
A course on the theory of measurements and errors; linear measurements; surveying principles and instruments; leveling; angles, bearings, and azimuths; stadia measurements; traversing-field aspects; traverse computations and adjustment; topographic surveying; triangulation; fundamentals of surveying for building and infrastructure construction; setting out horizontal and vertical curves; setting out engineering structures and construction projects.
- CIVE 370 Introduction to Information Technology 3 cr.**
The course introduces students to the main features of the Information Technology (IT) with emphasis on applications to civil engineering. Specifically, the course content includes presentation of several software applications and programming tools including: MS Word, Excel, PowerPoint, VBA, Visio, GIS and database technology and object-oriented programming.

- CIVE 371 Introduction to Information Technology (ConsE) 4 cr.**
A course introducing students to the main features of Information Technology (IT) with emphasis on applications to civil engineering. This course covers several software applications and programming tools including: FrontPage, Excel, VBA, Access, Visio, and database technology. The course also introduces students to basic programming skills using Matlab.
- CIVE 410 Structures II 3 cr.**
A course on the stability and determinacy of structures; energy theorems and applications to trusses, beams, and frames; analysis of statically indeterminate structures by flexibility (force) and stiffness methods; introduction to the direct stiffness method; influence lines for indeterminate structures. *Prerequisite: CIVE 311.*
- CIVE 420 Concrete I 3 cr.**
A course that covers the mechanical properties of concrete materials; ultimate strength theory of flexure and shear; flexural and shear design of beams; service load behavior; bond properties of reinforcing bars; design of solid and ribbed one-way slabs. *Prerequisite: CIVE 311.*
- CIVE 421 Concrete II 3 cr.**
This is a course that covers continuous beams, short columns, lender columns, and biaxially bent columns; wall footings, concentrically and eccentrically loaded single column footings, and combined footings; staircases; bearing walls; cantilever retaining *Prerequisites: CIVE 420.*
- CIVE 430 Engineering Geology 3 cr.**
This is a course that discusses the composition and properties of rocks; geologic processes; geologic hazards; geologic structure and engineering consequences; terrain analysis and geologic mapping; interpretation and use of geologic maps; application of geology to engineering practice. *Annually.*
- CIVE 431 Soil Mechanics and Laboratory 3 cr.**
A course on soil classification and index properties; soil structure and moisture; compaction; seepage; effective stress concept; compressibility and consolidation; stress and settlement analysis; shear strength; and laboratory experiments. *Prerequisite: CIVE 310 and CIVE 430.*
- CIVE 440 Hydraulics and Laboratory 3 cr.**
A course that covers flow in conduits, flow in open channels, flow measurements, and laboratory experiments. *Prerequisite: CIVE 340.*
- CIVE 441 Engineering Hydrology 3 cr.**
A course outlining hydrologic principles, rainfall-runoff analysis, flood routing, frequency analysis, and ground water hydrology.
- CIVE 450 Water and Wastewater Treatment and Laboratory 3 cr.**
A course that examines the quality and treatment methods of water and wastewater; testing for physical, chemical, and biological parameters. *Prerequisite: CIVE 350.*
- CIVE 460 Highway Engineering 3 cr.**
A course that examines road vehicle performance; principles of geometric design and highways; horizontal and vertical alignment; earthwork; intersections and interchanges; parking facilities; basic traffic models; queuing theory and traffic analysis; travel demand forecasting. *Prerequisite: CIVE 360.*
- CIVE 461 Transportation Engineering and Laboratory 3 cr.**
Introduction to the field of transportation engineering through presenting the basics of traffic engineering, traffic flow theory, and pavement design. The laboratory component consists of carefully structured experiments that reinforce students' understanding of the academic concepts and principles.

CIVE 480/580 Construction Management 3 cr.

A course that seeks to impart in students a sound understanding of the fundamental principles of construction management as applied to development of building and infrastructure projects. The course includes construction company and project organization, pre-construction activities, estimating and bidding, staffing for construction, macro-level planning and scheduling, and quality control.

CIVE 481/586 Construction Methods and Safety 3 cr.

A course that exposes students to the real world of construction and the complexity of managing machines, material and people with the one goal, to be on time and on budget while performing safely. The course content includes the selection of construction equipment and material based on applications, methods, and production requirements for earthmoving, heavy and building construction. *Prerequisite: CIVE 321.*

CIVE 482 Supervised Internship 1 cr.

Prerequisite: CIVE 480 and CIVE 481.

CIVE 483 Construction Systems Integration 3 cr.

The course exposes students to building systems and how to integrate them by best choosing materials and methods. The course will have particular emphasis on mechanical and electrical equipment in buildings, roofing, glazing, cladding, interior finishes, partitions, cost estimation and construction of the various systems. Presentation of professional construction documents including execution drawings, details, and specifications. *Prerequisite: CIVE 482.*

CIVE 484 Project Planning, Scheduling and Control 3 cr.

The course exposes students to basic concepts and methodology for making rational decisions in the design and implementation of real construction projects. Investigation of the planning activities and scheduling techniques used in construction projects. Scheduling: precedence diagrams, Critical Path Method (CPM), Program Evaluation Review Techniques (PERT), and computer applications (primavera). Project Control and Resource analysis: selection, time schedule, and costing for labor, materials and equipment. *Prerequisite: CIVE 483.*

CIVE 530 Foundation Engineering 3 cr.

A course that covers site investigations; evaluation of data from field and laboratory tests; estimation of stresses in soil masses; applications of principles of soil mechanics to determination of bearing capacity and settlement of spread footings, mats, single piles, and pile groups. *Prerequisite: CIVE 431.*

CIVE 581 Specifications and Cost Estimation 3 cr.

A course on the structure of construction documents and their interrelationships; bidding requirements; general and particular contract conditions; administrative and procedural requirements for construction; technical specifications; construction cost estimation processes; and unit rates determination and pricing.

CIVE 583 Construction Business Management and Financing 3 cr.

A course that covers the principles of business management of construction companies – theory as well as international and regional practice; an overview of construction business operations including strategic planning, organizational structure, marketing, accounting, financing, risk analysis, and quality; and the principles and sources of construction funding for contracting firms and projects.

CIVE 584 Design and Analysis of Construction Operations 3 cr.

A course that covers planning and modeling of construction operations, design of efficient processes, productivity and resource use considerations, site layout design and analysis, use of quantitative methods and queuing theory, effects of new technologies on construction operations, and an introduction to construction automation.

CIVE 585 **Building Information Modeling** **3 cr.**
A course on generating and managing building data during its life cycle; three-dimensional, real-time, dynamic building modeling techniques to increase productivity in building design and construction; producing the Building Information Model which encompasses building geometry, spatial relationships, geographic information, and quantities and properties of building components.

CIVE 587 **Infrastructure Construction and Evaluation** **3 cr.**
A course on urban requirements and engineering technologies and procedures for construction of infrastructure facilities including roads and pavements, bridges, water and sanitary networks, electric power lines, and telephone/communication lines. It also covers applications to urban and rural areas; nondestructive evaluation techniques for infrastructure systems; accelerated and full-scale testing; instrumentation, video logging, remote sensing, and nanotechnology.

Special Courses

CIVE 500 **Approved Experience** **0 cr.**
Students are placed for eight full weeks at a recognized consulting and/or contracting firm in Lebanon or abroad, in a capacity which ensures that they apply their knowledge and acquire professional experience in the field of Civil Engineering.

CIVE 501 **Final Year Project I** **1 cr.**
A chosen design topic and preparation of a detailed execution program for CIVE 502, through comprehensive research with the guidance and approval of the faculty.

CIVE 502 **Final Year Project II** **3 cr.**
A supervised project in groups of normally three students aimed at providing practical design experience in a civil and environmental engineering application. *Prerequisite: CIVE 501.*

CIVE 503 **Special Topics in Civil and Environmental Engineering** **3 cr.**

Structural Sequence

CIVE 610 **Advanced Structural Analysis** **3 cr.**
A course that offers a review of matrix algebra; basic principles of structural analysis: stiffness, flexibility, and energy methods; direct stiffness method for plane and space trusses and frames; linear and non-linear problems; special problems; and computer programming and applications. *Prerequisite: CIVE 410.*

CIVE 620 **Plain Concrete** **3 cr.**
This is a course that examines portland cements; aggregates; pozzolans; proportioning normal concrete mixtures; pumping concrete; consolidating, finishing, and curing concrete; durability; testing hardened concrete; high-strength concrete; light and heavy weight concretes; and hot and cold weather concreting.

CIVE 621 **Special Topics in Concrete** **3 cr.**
This is a course that reviews reinforced concrete (R/C) design; torsion in R/C members; wind load on structures; earthquake load and seismic design of structures; design of shear walls; design of corbels, brackets and deep girders; circular and rectangular water tanks; and spherical *Prerequisites: CIVE 410 and CIVE 421.*

CIVE 622 Prestressed Concrete 3 cr.

A course on material characteristics; prestress losses; working strength design procedures; composite construction; ultimate flexural strength and behavior; shear design; continuous prestressed concrete members. *Prerequisites: CIVE 420 and CIVE 421.*

CIVE 623 Bridges 3 cr.

A course that discusses types of bridges; influence lines; loads and their distribution on bridges; serviceability of bridges; methods of design of bridge deck, superstructure, and substructure. *Prerequisites: CIVE 410 and CIVE 421.*

CIVE 624 Steel Design 3 cr.

A course that examines loads on structures; philosophies of design: LRFD versus ASD; behavior, analysis, and design (according to AISC) of tension members, bolted connections, welded connections, compression members, and beams. *Prerequisite: CIVE 410.*

**CIVE 625 Strengthening and Rehabilitation of
Concrete Structural Systems 3 cr.**

This is a course on assessment of materials and structural deficiency using field test or analytical methods; repair and strengthening materials; strengthening and repair techniques; strengthening of structural members in flexure, shear and axial load; and upgrading of gravity load-designed buildings for earthquake load resistance. *Prerequisites: CIVE 410 and CIVE 421.*

CIVE 626 Earthquake Engineering 3 cr.

A course that examines the nature of earthquake ground motion; seismic hazard evaluation in engineering practice; response analysis of structures and effect of soil conditions on structural response and behavior under earthquake ground motion; design of structures under earthquake loading.

CIVE 632 Reliability Based Design of Civil Systems 3 cr.

This is a course that covers applications of reliability theory in assessing the safety and reliability of civil systems in the presence of uncertainty; decision making and risk analysis; definition of the probability of failure; modeling uncertainty in resistance and load; limit states and limit state functions; approximate and exact methods for assessing reliability; load and resistance factor design (LRFD) in structural and geotechnical engineering; basics of design code calibration; reliability assessments of existing structures, updating reliability with load tests.

Geotechnical Sequence

CIVE 630 Applied Foundation Engineering 3 cr.

A course on braced excavations, retaining structures, deep foundations, slope stability, and computer applications. *Prerequisite: CIVE 530.*

CIVE 631 Environmental Geotechnics 3 cr.

A course on geotechnical practice in environmental protection and restoration; methods of soil and site characterization for sifting of waste repositories and site restoration; influence of physical and chemical processes in soils on the evaluation of contaminant distribution; design of waste containment systems including landfills, slurry walls, and soil stabilization; the applicability and use of geosynthetics; and technologies for site restoration and cleanup. *Prerequisite: CIVE 431.*

- CIVE 648** **Climate Change and Water Resources** **3 cr.**
The course introduces students to the global issue of climate change and its potential impact on water resources and implications for their management particularly in the semi-arid MENA region. It explores the drivers of climate change, green house gases mitigation efforts, and adaptation options in the water resources sector with special emphasis on the Integrated Water Resources Management (IWRM) and adaptive management approach.
- CIVE 649** **Microbial Ecology and Molecular Biology for Engineers** **3 cr.**
A course that introduces students (undergraduate and graduate) from different engineering disciplines to the concepts and tools in microbial ecology and how to apply these concepts and tools to understand microbial communities underpinning environmental biotechnology processes. *Prerequisites: CHEM 202, BIOL 210, or equivalent.*
- CIVE 650** **Methods of Environmental Sampling and Analysis** **3 cr.**
A course on sampling techniques and instrumental methods in environmental sciences; determination of pollutants in water, air, and soil; analytical techniques; adaptation of procedures to specific matrices; case studies.
- CIVE 651** **Environmental Chemistry and Microbiology** **3 cr.**
A course that deals with organic, inorganic, and physical chemistry; chemical equilibrium; reaction kinetics; acidity, alkalinity; composition, morphology, and classification of micro-organisms; energy, metabolism, and synthesis; growth, decay, and kinetics; and biological water quality indicators. *Prerequisites: CHEM 202, BIOL 210, or equivalent.*
- CIVE 652** **Environmental Management and Decision Making** **3 cr.**
A course that deals with mathematical programming techniques, multi-objective optimization, and the generation of alternatives, as these are used in environmental systems analysis and management; as well as introducing how considerations such as economics, uncertainty, equity, and other sociopolitical parameters may influence environmental management and decision making.
- CIVE 653** **Water and Sewage Works Design** **3 cr.**
A course that examines the design of water and wastewater schemes, including design reports and a literature search on the development of conventional treatment processes. *Prerequisite: CIVE 450.*
- CIVE 654** **Solid Waste Management I** **3 cr.**
A course on nature and effects of solid wastes including hazardous wastes; engineering management principles, practices, and techniques for management of solid wastes administration; solid waste generation, storage, collection and transport, processing, resource recovery, and disposal; and trip to a local facility.
- CIVE 655** **Solid Waste Management II** **3 cr.**
A course on the design of solid waste disposal schemes, including design reports and a literature search on the development of conventional treatment and disposal processes. *Prerequisite: CIVE 654 or consent of instructor.*
- CIVE 656** **Air Pollution and Control I** **3 cr.**
An introductory course on air pollutants, sources, and effects; emissions estimates, regulations, and monitoring techniques; particulate matter characterization; meteorology and atmospheric dispersion; and air pollution control processes. *Prerequisite: CHEM 202 or equivalent.*
- CIVE 657** **Air Pollution and Control II** **3 cr.**
A course that examines process analysis, operational limitations, cost and performance, and evaluation of control process and equipment; and case studies, field visits, and inspection of industrial installations. *Prerequisite: CIVE 656 or consent of instructor.*

CIVE 658 Industrial/Hazardous Waste Management 3 cr.

A course that deals with sources, quantity, and quality of industrial wastes; basic industrial waste treatment processes; major industries, types of wastes, and existing treatment practices; disposal and fate of industrial wastes. *Prerequisites: CIVE 450 and CIVE 651, or consent of instructor.*

CIVE 659 Environmental Impact Assessment 3 cr.

A course that outlines theories and procedures of assessing environmental impact; analysis of the impact of development on various measures of environmental quality; and benefit-cost considerations in environmental impact assessment. *Prerequisites: CIVE 450, CIVE 654, and CIVE 656; or consent of instructor.*

Materials and Pavement Sequence

CIVE 660 Pavement Engineering 3 cr.

A course examining highway and airport pavement design; flexible and rigid pavement types and wheel loads; stresses in flexible and rigid pavements; pavement behavior under moving loads; soil stabilization. *Prerequisite: CIVE 461.*

CIVE 667 Highway Materials and Construction 3 cr.

The course covers various materials constituents in highway pavement structures with emphasis on asphalt concrete, aggregate-soil mixtures, geotextiles, and bituminous liquids. Materials properties, design, quality control and methods of construction will be described. Forensic studies, distress surveys, non-destructive and accelerated pavement testing are also discussed. *Prerequisite STAT 230.*

Transportation Sequence

CIVE 661 Urban Transportation Planning I 3 cr.

An introductory course on methods and models used in transportation planning with emphasis on the urban context. *Prerequisite: CIVE 461.*

CIVE 662 Traffic Engineering 3 cr.

A course outlining traffic engineering studies; traffic control of signalized and unsignalized intersections; signal control hardware and maintenance; arterial performance and operations; and network optimization. *Prerequisite: CIVE 461.*

CIVE 663 Transportation Systems Analysis 3 cr.

A course on transportation and traffic problems in modern society. Among the topics covered are travel forecasting problems and methods; theoretical techniques for traffic flow description and management; highway, railway, and runway capacity and performance characteristics; economic considerations; and cost functions.

CIVE 664 Design and Management of Transport Operations 3 cr.

A course that covers the application of quantitative techniques from operations research and probabilistic analysis to transportation problems. Applications covered include: pickup and delivery systems, emergency urban services, facility location, and network problems. *Prerequisite: STAT 230 or equivalent.*

CIVE 665 Transportation Economics 3 cr.

A course that investigates the application of economic principles to the evaluation of projects and policies in the transport sector such as transport project benefits, costs, and financing, and pricing in the transport sector.

CIVE 666 Transport Operations 3 cr.

A course that introduces probabilistic and optimization methods for designing efficient operations in freight carrier, airline, transit, and traffic modes. Topics include crew and vehicle scheduling in freight, airline, and transit modes; vehicle routing problems in carrier systems; runway and air traffic operations; operations control in transit services; and fundamental relations and models of traffic flow. *Prerequisite: CIVE 461.*

Common Courses

CIVE 586/481 Construction Methods and Safety 3 cr.

The course exposes students to the real world of construction and the complexity of managing machines and people with the one goal, to be on time and on budget while performing safely. The course content includes the selection and utilization of construction equipment such as scrapers, dozers, cranes, etc., based on applications, methods, and production requirements for heavy and building construction. Specific topics cover power generation, transmission, and output capacity of equipment engines as well as calculation of transport cycle times, concreting methods including mixing, delivery, and placement, design of forms for concrete walls and supported slabs and safety and inspection requirements for construction sites and projects. *Prerequisite: CIVE 320.*

CIVE 670 Computer Methods in Civil Engineering 3 cr.

A course on the use of the computer for analysis, design, and decision making in civil engineering, including programming, numerical, and CAD methods and applications. *Prerequisites: EECE 230 and CIVE 370.*

CIVE 671 Numerical Modeling 3 cr.

A course that deals with ordinary differential equations: initial-, boundary-, and characteristic-value problems; partial differential equations: steady state, time dependent, and oscillatory problems; techniques: Runge-Kutta, shooting, iterative, finite difference, and finite element methods.

CIVE 672 Introduction to Geographic Information Systems 3 cr.

An introductory course on Geographic Information Systems (GIS) and their applications in the planning and engineering fields, alternatives in computer-based graphics, data concepts and tools, network data management and planning applications, and implementation issues. This course satisfies the departmental requirements in all graduate engineering programs.

CIVE 673 Infrastructure Systems Management 3 cr.

A course on modeling and optimization methods and their application to inspection, performance prediction and maintenance decision making for the management of infrastructure systems.