

Department of Civil and Environmental Engineering

Chairperson:	El Fadel, Mutasem
Professor Emeritus:	Iliya, Raja
Professors:	Abdul Malak, Mohamed-Asem; Ayoub, George; Basha, Habib; El Fadel, Mutasem; Hamad, Bilal; Harajli, Muhamad; Mabsout, Mounir; Sadek, Salah
Associate Professors:	Abou Zeid, Maya; Chehab, Ghassan; Hantouche, Elie; Khoury, Hiam; Najjar, Shadi; Saad, George; Srouf, Issam
Assistant Professors:	Alameddine, Ibrahim; Bilbeisi, Rana; Dabaghi, Mayssa; Salam, Darine; Yeretzian, Aram
Adjunct Professor:	Kaysi, Isam
Part-Time Senior Lecturer:	Fawwaz, Youssef
Part-Time Lecturers:	Al-Naghi, Hani; El Meski, Fatima; Elsouri, Amer; Hatem Mousallem, Manal; Malaeb, Lilian; Nader, Halim
Part-Time Instructor:	Hage Ali, Nadine
Laboratories:	Al Hassanieh, Dima; Bittar, Yara; El-Khatib, Helmi; Zayyat, Ramez

Undergraduate Programs

The Department of Civil and Environmental Engineering (CEE) offers the degrees of Bachelor of Engineering (BE) with the major of Civil Engineering (CE) and Bachelor of Science (BS) with the major of 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 and research to prepare graduates for lifelong learning and productive careers while instilling in them an appreciation of leadership qualities, professionalism and ethics. It also fosters in them the ability to provide professional services of the highest quality to the community and to expand, through teaching and research, the knowledge and technology base in civil and environmental engineering.

Bachelor of Engineering (BE)

Major: Civil Engineering

Program Educational Objectives

The objectives of the CE program are to see our students 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 to and successfully complete advanced degrees in leading universities around the world;
- and leaders in their profession and in the service of their community.

Curriculum

Term I (Fall)		Credits
FEAA 200	Introduction to Engineering and Architecture	3
CIVE 201	Engineering Drawings and Tools	3
MATH 201	Calculus and Analytical Geometry III	3
CHEM 202	Introduction to Environmental Chemistry (or CIVE 251)	3
CHEM 203	Introductory Chemical Techniques (or CIVE 251L)	2
ARAB 2nn	Arabic Elective	3
		Total 17

Term II (Spring)		Credits
CIVE 210	Statics	3
MATH 202	Differential Equations	3
PHYS 210	Introductory Physics II	3
PHYS 210L	Introductory Physics Laboratory II	1
ENGL 203	Academic English	3
Hum 2nn	Humanities Elective I	3
		Total 16

Term III (Summer)		Credits
CIVE 301	Surveying	2
STAT 230	Introduction to Probability and Random Variables	3
SoSc 2nn	Social Sciences Elective I	3
		Total 8

Term IV (Fall)		Credits
CIVE 310	Mechanics of Materials	3
CIVE 370	Construction Materials and Technologies	3
EECE 231	Introduction to Programming with C++ and MATLAB	3
ENGL 206	Technical English	3
MATH 2nn	Mathematics Elective	3
Hum 2nn	Humanities Elective II	3
		Total 18

Term V (Spring)		Credits
CIVE 311	Theory of Structures	3
CIVE 340	Fluid Mechanics and Laboratory	3
MATH 251	Numerical Computing	3
BIOL 2nn	Biology Elective	3
INDE 410	Engineering Ethics	3
Hum 2nn	Humanities Elective III	3
		Total 18

Term VI (Summer)		Credits
CIVE 330	Engineering Geology (or Geology Elective)	3
INDE 301	Engineering Economy	3
SoSc	Social Sciences Elective II	3
		Total 9

Term VII (Fall)		Credits
CIVE 413	Concrete Design I	3
CIVE 430	Soil Mechanics and Laboratory	3
CIVE 440	Hydraulics and Laboratory	3
CIVE 550 or 551	Water Treatment and Laboratory or Wastewater Treatment and Laboratory	3
CIVE 460	Transportation Engineering and Laboratory	3
		Total 15

Term VIII (Spring)		Credits
CIVE 421	Construction Management	3
CIVE 431	Foundation Engineering	3
CIVE 54n	Hydrology Elective	3
CIVE n5n	Environmental Elective	3
CIVE 461	Highway Engineering	3
		Total 15

Term IX (Summer)		Credits
CIVE 400	Approved Experience	0
		Total 0

Term X (Fall)		Credits
CIVE 401	Final Year Project I	3
CIVE 41n	Structures Elective	3
CIVE 5nn/6nn	CEE Technical Elective	3
CIVE 5nn/6nn	CEE Technical Elective	3
CIVE 5nn/6nn	CEE Technical Elective	3
		Total 15

Term XI (Spring)		Credits
CIVE 402	Final Year Project II	3
CIVE 42n	Construction Elective	3
CIVE 5nn/6nn	CEE Technical Elective	3
CEE FEA	Technical Elective	3
		Total 12
Total Credit Hours:		143

Bachelor of Science (BS)

Major: Construction Engineering (ConsE)

Program Educational Objectives

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

- engineers who hold central positions in local, regional and international construction engineering practice;
- engineers who are involved in landmark projects and who contribute to the advancement of the local and regional construction industry;
- and leaders in their profession and in the service of their community.

Curriculum

Term I (Fall)		Credits
FEAA 200	Introduction to Engineering and Architecture	3
CIVE 201	Engineering Drawings and Tools	3
MATH 201	Calculus and Analytical Geometry III	3
CHEM 202	Introduction to Environmental Chemistry (or CIVE 251)	3
CHEM 203	Introductory Chemical Techniques (or CIVE 251L)	2
ARAB 2nn	Arabic Elective	3
		Total 17

Term II (Spring)		Credits
CIVE 210	Statics	3
MATH 202	Differential Equations	3
PHYS 210	Introductory Physics II	3
PHYS 210L	Introductory Physics Laboratory II	1
ENGL 203	Academic English	3
Hum 2nn	Humanities Elective I	3
		Total 16

Term III (Summer)		Credits
CIVE 301	Surveying	2
STAT 230	Introduction to Probability and Random Variables	3
SoSc 2nn	Social Sciences Elective	3
		Total 8

Term IV (Fall)		Credits
CIVE 310	Mechanics of Materials	3
CIVE 370	Construction Materials and Technologies	3
EECE 231	Introduction to Programming with C++ and MATLAB	3
ENGL 206	Technical English	3
MATH 2nn	Mathematics Elective	3
		Total 15

Term V (Spring)		Credits
CIVE 311	Theory of Structures	3
CIVE 340	Fluid Mechanics and Laboratory	3
MATH 251	Numerical Computing	3
INDE 410	Engineering Ethics	3
BIOL 2nn	Biology Elective	3
		Total 15

Term VI (Summer)		Credits
CIVE 330	Engineering Geology (or Geology Elective)	3
INDE 301	Engineering Economy	3
ECON 212	Elementary Macroeconomic Theory	3
		Total 9

Term VII (Fall)		Credits
CIVE 413	Concrete Design	3
CIVE 421	Construction Management	3
CIVE 430	Soil Mechanics and Laboratory	3
CIVE 440	Hydraulics and Laboratory	3
Hum 2nn	Humanities Elective II	3
		Total 15

Term VIII (Spring)		Credits
CIVE 422	Construction Methods and Safety	3
CIVE 423	Construction Planning and Scheduling	3
CIVE 522	Building Construction and Estimating	3
CIVE 461	Highway Engineering	3
Hum 2nn	Humanities Elective III	3
		Total 15
Term IX (Summer)		Credits
CIVE 400	Approved Experience	0
		Total 0
Total Credit Hours: 110		

Elective Courses

- **List of Biology Elective Courses:** BIOL 201, BIOL 202, BIOL 209, BIOL 210, BIOL 250, BIOL 252, BIOL 255, BIOL 258, BIOL 259, CIVE 252
- **List of Chemistry Elective Courses:** CHEM 202, CIVE 251
- **List of Chemistry Lab Elective Courses:** CHEM 203, CIVE 251L
- **List of Geology Elective Courses:** GEOL 201, GEOL 211, CIVE 330
- **List of Mathematics Elective Courses:** MATH 211, MATH 212, MATH 218, MATH 281

General Education Requirements

Civil Engineering Major: Students are required to complete 12 credits in the humanities including INDE 410, 6 credits in the social sciences, 6 credits in English: ENGL 203 and ENGL 206, and 3 credits in Arabic.

Construction Engineering Major: Students are required to complete 12 credits in the humanities including INDE 410, 6 credits in the social sciences including ECON 212, 6 credits in English: ENGL 203 and ENGL 206, and 3 credits in Arabic.

Course Descriptions

Common Courses

FEAA 200 Introduction to Engineering and Architecture 3 cr.
The course is designed to familiarize first year students with the different disciplines in Engineering and Architecture, including: Architecture, Civil, Mechanical, Electrical, Chemical, Industrial and technologies used in the fields. The course takes a unique interdisciplinary approach to the field and introduces the related disciplines in the world of engineering and architecture. One key objective is to promote interdisciplinary interaction and innovative thinking. The course is organized into modules covering the different disciplines within the Maroun Semaan Faculty of Engineering and Architecture (MSFEA). The last module of the class showcases interdisciplinary projects demonstrating interactions among the different fields. The lectures explain as applicable to each discipline, through examples, notions of problem solving, design thinking, process of invention and innovation, environmental and civic responsibility, and measures of success in aesthetics and performance. The course project is a key component of the course. It is interdisciplinary in nature bringing ideas and solutions from all disciplines in engineering and architecture. *Annually.*

CIVE 201 Engineering Drawings and Tools 3 cr.
An introductory course that aims to introduce students to the basics of engineering drawing and mapping through the use of Autodesk's Revit and ESRI's ArcGIS software packages.

CIVE 301 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. *Prerequisites: CIVE 201 and CIVE 210.*

CIVE 400 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 that ensures they apply their knowledge and acquire professional experience in the field of Civil Engineering. *Prerequisite: Fourth year.*

CIVE 401 Final Year Project I 3 cr.
A chosen design topic and preparation of a detailed execution program for CIVE 402 through comprehensive research with the guidance and approval of the faculty. *Prerequisite: CIVE 400.*

CIVE 402 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 401.*

CIVE 403 Special Topics in Civil and Environmental Engineering 3 cr.

CIVE 501 Computer Methods in Civil Engineering 3 cr.
A course on the use of computers for analysis, design and decision-making in civil engineering, including programming, numerical, and CAD methods and applications. *Prerequisite: EECE 231.*

CIVE 600A Seminar in Civil Engineering 0 cr.
A seminar that consists of current research or applied projects presented by faculty members, students or invited speakers.

CIVE 600B Seminar in Environmental Engineering and Sciences 0 cr.
A seminar that consists of current research or applied environmental projects presented by faculty members, students or invited speakers.

CIVE 601 GIS and Geospatial Data Modeling 3 cr.
A course that examines the concepts and principles of Geographic Information System (GIS). It provides coverage of state-of-the-art GIS methods and tools: spatial and terrain analysis, geostatistical analysis, time series analysis and development of GIS integrated models.

CIVE 602 Experimental Design and Statistical Analysis for Engineers 3 cr.
A course that covers the main steps required to efficiently plan, conduct, analyze and interpret the results from experimental and observational studies. The course focuses on statistical inference and modeling. Topics covered include ANOVA, t-tests, regression models and non-parametric tests. The course involves working within a statistical modeling environment.

CIVE 603 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 and finite difference methods. *Prerequisite: MATH 251.*

Structural Sequence

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, moment diagrams of beams and simple frames; friction; center of gravity and centroid; area moment of inertia; computer applications. *Pre- or corequisite: 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 Theory of Structures 3 cr.
A course covering review of principles of statics; analysis of statically determinate plane frames; deflection of statically determinate beams; introduction to indeterminate structural analysis; influence lines; computer applications; a project on building modeling and assessment. *Prerequisites: CIVE 310, MATH 202 and PHYS 210.*

CIVE 411 Indeterminate Structural Analysis 3 cr.
A course covering review of basic concepts of structural analysis; equilibrium, stability, indeterminacy and degrees of freedom; indeterminate analysis of trusses; indeterminate analysis of beams and frames; influence lines for statically indeterminate structures. *Prerequisite: CIVE 311.*

CIVE 412 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, welding fundamentals and groove welds, compression members and beams. *Prerequisite: CIVE 311.*

CIVE 413 Concrete Design 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 414 Concrete Design II 3 cr.
A course that covers continuous beams, short columns, slender columns and biaxially bent columns; wall footings, concentrically and eccentrically loaded single column footings and combined footings; staircases; bearing walls; cantilever retaining. *Prerequisite: CIVE 413.*

CIVE 610 Numerical Methods in Structural Analysis 3 cr.
A course that introduces the matrix approach for the modeling and analysis of structural systems; computer modeling/analysis using specialized software (SAP2000); computer implementation and code development; nonlinear analysis of frames. *Prerequisites: CIVE 411 and EECE 231.*

CIVE 611 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. *Prerequisite: CIVE 311.*

CIVE 612 Advanced Steel Design 3 cr.
A course that investigates stability, column strength, beam-columns, composite steel-concrete construction, plate buckling, plate girders, torsion, and combined torsion and bending; eccentrically loaded connections, influence of connection stiffness on moment demand and general moment connection. *Prerequisite: CIVE 412.*

CIVE 613 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 pre-stressed concrete members. *Prerequisite: CIVE 413.*

CIVE 614 Special Topics in Concrete 3 cr.
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, conoidal, and ellipsoidal domes I. *Prerequisite: CIVE 414.*

CIVE 615 Strengthening and Rehabilitation of Concrete Structural Systems 3 cr.
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 311 and CIVE 413.*

CIVE 616 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. *Prerequisite: CIVE 411.*

CIVE 710 The Finite Element Method 3 cr.
A course that introduces basic elements; interpolation and shape functions; variational formulation methods; Galerkin and weighted residual methods; isoparametric elements; numerical integration; error estimation and modeling issues; finite elements in structural dynamics. *Prerequisite: CIVE 610.*

CIVE 711 Advanced Mechanics of Solids 3 cr.
A course that covers theories of stress and strain; generalized Hooke's law; modes of failure, failure criteria; energy principles and applications; torsion; beams on elastic foundations; introduction to the theory of plates; thin-wall and thick-wall cylinder. *Prerequisite: CIVE 411.*

CIVE 712 Structural Dynamics 3 cr.
A course on analysis of vibration of single degree, multi-degree and infinite degree of freedom systems; free and forced vibration response; analysis of dynamic response by approximate methods; introduction to earthquake engineering. *Prerequisite: CIVE 411.*

CIVE 713 Behavior of Reinforced Concrete Members 3 cr.
A course on building codes; limit state design; mechanical characteristics of concrete and steel reinforcement; creep and shrinkage; flexure: moment-curvature and force-deformation relationships; columns: axial force-moment-curvature relationships; shear: mechanisms of shear resistance; and truss analogy; bond and anchorage of reinforcement. *Prerequisite: CIVE 414.*

CIVE 714 Seismic Design of Reinforced Concrete Structures 3 cr.
A course on the seismic behavior and design of reinforced concrete structures; introduction to concepts of seismic design and performance-based earthquake engineering; mechanical behavior of steel reinforcement, concrete and confined concrete under monotonic and cyclic loading; seismic behavior, analysis and design of reinforced concrete elements and systems; design of special structural/shear wall systems; design of special moment resisting frames. *Prerequisite: CIVE 411 or CIVE 414.*

Construction Engineering and Management Sequence

CIVE 421 Construction Management 3 cr.
A course that seeks to impart in students a sound understanding of the construction company and project organization, pre-construction activities, estimating and bidding, staffing for construction, macro-level planning and scheduling, and quality control.

CIVE 422 Construction Methods and Safety Management 3 cr.
A course that exposes students to the tools needed for estimating, planning and directing operations in building construction and heavy civil projects. The course addresses equipment, methods, productivity, ownership and operating costs, and safety management. *Prerequisite: CIVE 370.*

CIVE 423 Construction Planning and Scheduling 3 cr.
A course on CPM, precedence network, schedule control, codes, collaborative planning, resource management, priority rules and leveling, earned value, schedule reduction, PERT, line of balance scheduling, the Last Planner System, Primavera P6, Microsoft Project and VICO control.

CIVE 520 Construction Contract Administration 3 cr.
The course deals with contract documents, with focus on specifications structure, procedural requirements, specifying methods and the basis for unit rate estimation. It covers the engineer's roles along with contract administration issues. *Prerequisite: CIVE 421.*

CIVE 522 Building Construction and Estimating 3 cr.
A course that exposes students to different building systems (concrete, masonry, steel, waterproofing, mechanical, electrical, etc.) and how to price them by choosing the best materials and methods. The use of drawings and specifications will also be covered. *Prerequisites: CIVE 400 (site work) and CIVE 421.*

CIVE 524 Logistics, Technologies, and Productivity Concepts 3 cr.
The course covers construction site layout, team organization, information flow and complexities. Focus is on productivity improvement approaches, data gathering for analysis of construction operations, and issues related to process innovation and automation.

CIVE 525 Design of Temporary Support Structures 3 cr.
A course that covers design and construction of temporary support structures used in the construction industry, including concrete formwork, scaffolding, caissons, cofferdams and dewatering systems.

CIVE 620 Pre-Project Planning and Feasibility Analysis 3 cr.
A course covering the studies needed to make a go-ahead decision, including assimilation of client needs, surveys of project area and infrastructure conditions, scope validation, team development, project planning and cost estimation, and financial feasibility. *Prerequisite: CIVE 421 or equivalent.*

CIVE 621 Design Management for Large Projects 3 cr.
The course covers the characteristics of the design phase, design team selection, and design services agreement formation and negotiation. It focuses on value engineering and management, constructability considerations and project cost management during design.

CIVE 622 Advanced Topics in Construction Management (Blended) 3 cr.
A course focusing on the construction phase of a project's lifecycle. Topics include: site organization structure, construction safety, labor management, materials procurement systems, site information management, scheduling, project controls and sustainability. *Prerequisite: CIVE 421 or equivalent.*

CIVE 623 Construction Project Management 3 cr.
The course offers an extended overview of project management. It covers integrated planning-estimating-scheduling concept; project time, budget and quality baselines; materials management and subcontracting issues; and integrated project cost-time control. *Prerequisite: CIVE 421 or equivalent.*

CIVE 624 Building Information Modeling 3 cr.
A course that covers Building Information Model (BIM) use and benefits in design and construction. It addresses collaborative design, clash detection, level of development (LOD), BIM contracts, automated code checking, simulation, BIM and lean applications, and integrated project delivery.

CIVE 625 IT Applications in Construction 3 cr.
A course that covers computing tools impacting the construction industry such as mobile sensing, instrumentation and information systems to support field engineering tasks and computerized systems applications to perform specific functions, such as estimating, scheduling and cost control.

CIVE 626 Lean Construction Methods and Applications (Blended) 3 cr.
A course on lean theory, production control, value stream mapping, process improvement, project definition, lean design, integrated project delivery, advanced lean scheduling, risk assessment, budget under uncertainty and project monitoring. *Prerequisite: CIVE 421.*

CIVE 627 Construction Systems Analysis and Simulation 3 cr.
A course that covers planning and simulation modeling of construction operations, design of efficient processes, construction productivity and resource use considerations, production system design, construction supply chain management and analysis of construction systems.

CIVE 628 Sustainable Building Design and Construction 3 cr.
A course that covers principles of sustainable design and construction, including lifecycle assessment, economic and environmental impacts, carbon footprint, and green building rating systems such as LEED and BREEAM.

CIVE 629 Construction Business Management 3 cr.
A course that covers the principles of business management of construction companies and projects including financial management, accounting, costs and profits management, cash flows management, evaluation of sources of construction funding and financial decisions analysis. *Prerequisite: CIVE 370.*

CIVE 720 Construction Technology for Tall Buildings 3 cr.
A course on the latest construction practices and processes for tall buildings from foundation to roof. It covers advanced methods, materials, equipment and systems used for the construction of tall buildings, as well as principles of sustainable construction. *Prerequisite: CIVE 422.*

CIVE 721 Advanced Scheduling Analysis 3 cr.
A course that provides advanced techniques in construction scheduling. It examines monitoring, updating and controlling the project schedule. It introduces the methods used in performing forensic scheduling analysis. *Prerequisite: CIVE 423.*

CIVE 722 Project Deliverance and Contracts 3 cr.
The course offers an overview of project delivery organizations, risk considerations and contracts. It covers the elements of construction contracts, with emphasis on contract formation, substantial completion and close-out processes. *Prerequisite: CIVE 421 or equivalent.*

CIVE 723 Dispute Resolution on Projects 3 cr.
The course covers construction contract conditions governing claims and disputes. Focus is on claim involvement and administration (including issues dealing with time barring, notification and substantiation), ADR methods and amicable settlement. *Prerequisite: CIVE 421.*

CIVE 724 Mediation of Engineering Disputes 3 cr.
This course focuses on the use of mediation for resolving construction related disputes. Topics include: dispute avoidance in construction, alternative dispute resolution techniques, and the mechanics of mediation and negotiation. *Prerequisite: CIVE 520.*

CIVE 725 Construction Decisions Under Uncertainty 3 cr.
A course that covers construction project and organization decisions for the uncertain future. The course addresses decision theory, competitive bid analysis, probabilistic modeling and simulation, and multiple regression analysis in managing construction. *Prerequisite: STAT 230.*

Geotechnical Sequence

CIVE 330 Engineering Geology 3 cr.
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.

CIVE 430 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. *Prerequisites: CIVE 310 and CIVE 330.*

CIVE 431 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 430.*

CIVE 631 Applied Foundation Engineering 3 cr.
A course on braced excavations, retaining structures, deep foundations, slope stability and computer applications. *Prerequisite: CIVE 431.*

CIVE 632 Soil Behavior 3 cr.
A course on soil mineralogy, soil formation and composition; influence of geological factors on properties; colloidal phenomena in soils; soil structure; analysis of conduction phenomena (hydraulic, diffusive, thermal and electrical); compressibility, strength and deformation properties. *Prerequisite: CIVE 430.*

CIVE 633 Soil and Site Improvement 3 cr.
A course that covers compaction, admixture stabilization, foundation soil treatment, reinforced soil and composite materials, and material sites reclamation.

CIVE 634 Shear Strength of Soils 3 cr.
A course that covers stresses within a soil mass, tests to measure stress strain properties, stress-strain relationships, shear strength, drained and undrained conditions, constitutive models, and failure criteria applications. *Prerequisite: CIVE 430.*

CIVE 635 Earth Dams 3 cr.
A course that examines hydraulic dams, rolled earth dams, homogenous dams, thin core dams, filters, causes of dam failures, seepage control and seismic stability of dams.

CIVE 636 Geotechnical Earthquake Engineering 3 cr.
A course on causative mechanisms and characteristics of earthquakes; evaluation dynamic soil properties local site response; seismic soil-structure interaction; evaluation and mitigation of soil liquefaction; seismic code provisions and additional current topics. *Prerequisite: CIVE 430.*

Water Resources Sequence

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 and laboratory experiments. *Prerequisites: CIVE 210, MATH 201 and PHYS 210.*

CIVE 440 Hydraulics and Laboratory 3 cr.
A course that covers flow in conduits, flow in open channels, flow measurements, design of basic hydraulic structures and laboratory experiments. *Prerequisites: CIVE 340, MATH 202, MATH 251 and ENGL 206.*

CIVE 541 Engineering Hydrology 3 cr.
A course outlining hydrologic principles, rainfall-runoff analysis, flood routing, frequency analysis and ground water hydrology. *Prerequisites: CIVE 340 and MATH 202.*

CIVE 542 Urban Hydrology 3 cr.
A course covering design rainfall, infiltration, overland flow, channel flow, storm sewer hydraulics, stormwater detention and simulation models. *Prerequisite: CIVE 440.*

CIVE 640 Advanced Hydraulics 3 cr.
A course that covers closed conduit flow, water distribution systems, transient analysis, open channel flow, flood control, culvert hydraulics and design of various hydraulic structures. *Prerequisite: CIVE 440.*

CIVE 641 Surface Water Hydrology 3 cr.
A course on design storm, rainfall-runoff modeling, flood routing, reservoir routing, simulation models and stochastic hydrology. *Prerequisite: CIVE 541 or equivalent.*

CIVE 642 Groundwater Hydrology 3 cr.
A course that deals with properties of groundwater, Darcy's law, steady groundwater flow, unsteady groundwater flow, well hydraulics, unsaturated flow, sea-water intrusion and numerical modeling. *Prerequisite: CIVE 541.*

CIVE 644 Coastal Engineering 3 cr.
A course on small-amplitude wave theory (linear theory); finite-amplitude wave theory (nonlinear theory); cnoidal wave theory; solitary wave theory; wave refraction, diffraction and reflection; wave forces and interaction with man-made structures; and design of maritime structures e.g. breakwaters. *Prerequisite: CIVE 440.*

CIVE 645 Surface Water Quality Modeling and Management 3 cr.
An introductory course on surface water quality pollution problems in streams, rivers, lakes, reservoirs and estuaries with a focus on both the quantitative modeling aspects of surface water quality as well as the management and policy aspects of it. Both mechanistic and empirical models for assessing the status of surface water bodies are introduced.

CIVE 647 Water Resource Systems: Planning and Management 3 cr.
A course that introduces principles demonstrating steps in engineering policy planning as it applies to water resources management. Emphasis will be placed on systems and socioeconomic analysis, conflict management and concepts in strategic assessment.

CIVE 648 Climate Change and Water Resources 3 cr.
An introductory course on global climate change and its potential impacts on water resources and related sectors. It explores drivers of climate change, greenhouse gases emissions and mitigation efforts, and adaptation options with emphasis on Integrated Water Resources Management.

CIVE 740 Transport Phenomena in Surface and Subsurface Waters 3 cr.
A course on advection, diffusion and dispersion of pollutants; transport in rivers and estuaries; transport in groundwater; numerical modeling; design of wastewater discharge system.

Environmental Sequence

CIVE 251 Environmental Chemistry 3 cr.
A course that introduces the basic principles of environmental chemistry and discusses example applications from the natural and engineered worlds.

CIVE 251L Introductory Chemical Analysis Laboratory 2 cr.
A laboratory course on chemical qualitative and quantitative analysis of environmental samples. The course introduces fundamental chemical analytical and physicochemical principles in environmental chemistry. *Pre- or corequisite: CIVE 251.*

CIVE 252 Environmental Microbiology 3 cr.
A course that introduces basic principles of environmental microbiology. It discusses example applications from the natural and engineered worlds. The main goals of this course are to present an overview of important microorganisms involved in environmental systems; their ecology, interactions with various pollutants, and beneficial or harmful effects on humans.

CIVE 451 Contemporary Environmental Issues 3 cr.
Introduction to environmental quality and the technical background necessary for understanding environmental issues, controlling environmental degradation, and preserving air and water quality. Material balance concepts for tracking substances in the environmental systems.

CIVE 550 Water Treatment and Laboratory 3 cr.
A course that examines the quality and principles of municipal and industrial water treatment processes and methods of testing for physical, chemical and biological parameters. *Prerequisite: CIVE 251 or equivalent, or consent of instructor.*

CIVE 551 Wastewater Treatment and Laboratory 3 cr.
A course that examines the quality and principles of municipal wastewater treatment processes and methods of testing for physical, chemical and biological parameters. *Prerequisite: CIVE 252 or equivalent, or consent of instructor.*

CIVE 552 Waste Management and Treatment 3 cr.
A course on engineering principles, practices and techniques for the management of solid wastes: sources, composition, properties, impacts, generation, storage, collection and transport, processing, resource recovery and disposal.

CIVE 553 Environmental Biotechnology 3 cr.
A course that examines current and emerging environmental biotechnologies used for environmental quality evaluation, monitoring and remediation of contaminated environments; and provides students with working knowledge of the science that underpins them. *Prerequisite: CIVE 252 or equivalent, or consent of instructor.*

CIVE 555 Air Quality Management 3 cr.
A course on the principles, practices and techniques for the management of air pollution: types, sources, properties, impacts, standards, control technologies, atmospheric dispersion, emissions and indoor air quality.

CIVE 650 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 550 or CIVE 551, or consent of instructor.*

CIVE 651 Processes in Water and Wastewater Treatment 3 cr.
A course on sedimentation, filterability, permeability and fluidization, ion exchange, aeration, flotation, membrane filtration and aerobic digestion. Experimental applications of processes. *Prerequisites: CIVE 251 and CIVE 252, or equivalent; or consent of instructor.*

CIVE 652 Landfill Engineering Design 3 cr.
A course on solid waste disposal with emphasis on design development of landfill elements (site selection and characterization, gas extraction and management, leachate collection and management, liners, covers, closure and post-closure monitoring. *Prerequisite: CIVE 552 or consent of instructor.*

CIVE 653 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 microorganisms; energy, metabolism and synthesis; growth, decay and kinetics; and biological water quality indicators. *Prerequisites: CIVE 251 and CIVE 252, or equivalent; or consent of instructor.*

CIVE 654 Environmental Bioremediation 3 cr.
A course that discusses the application of biological treatment for the remediation of contaminated environments, and highlights current engineering methods/design used to enhance biodegradation. *Prerequisites: CIVE 251 and CIVE 252, or equivalent; or consent of instructor.*

CIVE 655 Air Pollution and Control 3 cr.
A course that examines processes and design equipment for the control of particulates and gaseous emissions. *Prerequisite: consent of instructor.*

CIVE 656 Environmental Impact Assessment 3 cr.
A course on procedures of assessing/preparing/reviewing/presenting environmental impacts of developmental projects/facilities: industrial facilities, waste management/disposal, wastewater treatment, transportation, dams and reservoirs, irrigation/drainage schemes, coastal zone developments, natural resource management, etc. *Prerequisite: Fourth year status or consent of instructor.*

CIVE 657 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. *Prerequisites: CIVE 251 and CIVE 252, or equivalent; or consent of instructor.*

CIVE 658 Industrial Waste Management 3 cr.
A course on engineering principles, practices and techniques for the management of industrial-hazardous wastes: sources, generation, properties. Impacts and auditing of industrial facilities. Basic treatment processes and disposal methods. Site remediation. *Prerequisite: Fourth year status or consent of instructor.*

CIVE 659 Environmental and Water Conflict Management 3 cr.
A course on the development of case studies in environmental and water conflict management taught under a framework of role-play of opponent's perspective and the decision-making thereof.

CIVE 751 Wastewater Reclamation and Reuse 3 cr.
A course that examines environmental issues in water reuse, risk assessment, water reclamation technologies, storage of reclaimed water, usage of reclaimed water, and planning of wastewater reclamation and reuse. *Prerequisite: CIVE 551.*

CIVE 755 Air Pollution Modeling 3 cr.
A course that deals with mathematical models, air pollution meteorology, plume rise, dispersion and atmospheric chemistry, meteorological models, as well as Gaussian, statistical and other special application models. *Prerequisite: CIVE 555 or consent of instructor.*

Transportation Sequence

CIVE 460 Transportation Engineering and Laboratory 3 cr.
An introductory course to the field of transportation engineering through presenting the basics of traffic engineering, traffic flow theory and airport planning. The laboratory component consists of field experiments that reinforce students' understanding of academic concepts and principles. *Prerequisites: STAT 230 and ENGL 206.*

CIVE 461 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; pavement design; parking facilities; and highway planning (travel demand forecasting).
Prerequisites: CIVE 201 and CIVE 301.

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. Topics include travel patterns in urban areas; data requirements for planning and data collection techniques; transportation/land-use interaction; travel demand and network models; transport supply options; and evaluation techniques. *Prerequisite: CIVE 460 or 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 460.*

CIVE 663 Transportation Systems Analysis 3 cr.
A course that introduces methods, models and applications of transportation systems analysis focusing on both supply/performance and demand/economics. *Prerequisite: CIVE 460 or CIVE 461.*

CIVE 664 Design and Management of Transport Operations 3 cr.
A course on 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, transit modes; vehicle routing and facility location problems in carrier systems; runway and air traffic operations; and reliability in transit services. *Prerequisites: CIVE 460 and 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. *Prerequisite: CIVE 461.*

CIVE 666 Public Transportation 3 cr.
A course on public transportation modes and services; single route, network and strategic planning; tasks involved in system operations; management of public transportation organizations; privatization issues. *Prerequisite: CIVE 460 or CIVE 461.*

CIVE 761 Urban Transportation Planning II 3 cr.
A course examining advanced topics in urban transportation planning, transportation systems management techniques, travel demand analysis and discrete choice modeling of travel demand. *Prerequisite: CIVE 661.*

CIVE 762 Traffic Flow Theory 3 cr.
A course on characteristics of traffic flow, density and speed; models describing traffic flow; hydrodynamic analogue; and computer simulation models. *Prerequisite: CIVE 460.*

Materials Sequence

CIVE 370 Construction Materials and Technologies 3 cr.
An introductory course on 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 students with materials, testing methods, equipment and standards.
Corequisite: CIVE 310.

CIVE 670 Concrete Technology 3 cr.
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 671 Pavement Engineering 3 cr.
A course that examines 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. The course covers empirical, mechanistic-empirical and mechanistic design methodologies. *Prerequisite: CIVE 461.*

CIVE 672 Highway Materials and Construction 3 cr.
A course that 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. *Prerequisite: STAT 230.*

CIVE 770 Viscoelastic Behavior of Construction Materials 3 cr.
A course that introduces students to viscoelastic behavior of construction materials, particularly asphalt concrete and polymer composites. The course covers basic concepts in material characterization, rheology, time-temperature superposition principles, in addition to linear and nonlinear viscoelastic models. *Prerequisite: Graduate standing.*

CIVE 771 Pavement Management Systems 3 cr.
A course that covers the principles of pavement management including types of pavement systems, common distresses and their assessment, pavement evaluation and rating systems, in addition to performance prediction and lifecycle analysis. Various field assessment methods in addition to non-destructive and accelerated tests will be discussed and demonstrated. Maintenance and rehabilitation techniques will be compared with emphasis on selection of the most efficient, environment-friendly and cost-effective approaches. Students will utilize computer applications using GIS, regional and international inventory data, and relevant software packages. *Pre- or corequisite: CIVE 671 or CIVE 672.*

Multidisciplinary Courses

CIVE 481 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 681 Evaluation of Cost Alternatives 3 cr.
A course that covers the principles of economic evaluations using concepts of time value of money to compare alternatives related to construction, design and real property development.

CIVE 682 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.

CIVE 683 Reliability Based Design of Civil Systems 3 cr.
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; load and resistance factor design (LRFD) in structural and geotechnical engineering; basics of design code calibration.

CIVE 684 Environmental Geotechnics 3 cr.
A course on geotechnical practice in environmental protection and restoration; influence of physical and chemical processes in soils on the evaluation of contaminant distribution; design of waste containment systems, slurry walls and soil stabilization; the applicability and use of geosynthetics; and technologies for site restoration and cleanup. *Prerequisite: CIVE 430.*

CIVE 685 Environmentally Sustainable Renewable Energy Sources 3 cr.
A course that covers basic principles, potentials and limitations of various renewable energy sources and technologies, including solar energy, hydroelectricity, wind energy, bio-energy, fuel cells, batteries and supercapacitors. Sustainability and impact of renewable energy sources on the environment will be discussed. *Prerequisite: CIVE 251 or CHEM 202.*

CIVE 686 Environmentally Responsive Buildings 3 cr.
A course that enhances knowledge pertaining to design aspects and application possibilities of climate responsive and environmentally friendly buildings. The impact of using construction building materials throughout the lifecycle of projects will also be discussed. At the end of the course, students will be equipped with the necessary knowledge that will enable them to make informed decisions regarding green projects in their careers.

Special Courses

CIVE 690 Special Projects 3 cr.

CIVE 691 Special Topics in Civil and Environmental Engineering 3 cr.

CIVE 692 Advanced Topics in Civil and Environmental Engineering 3 cr.