Department of Civil and Environmental Engineering

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Professor Emeritus: Iliya, Raja
Professors: Ayoub, George; Basha, Habib; El Fadel, Mutasem; Hamad, Bilal; Harajli, Mohamed; Kaysi, Isam; Mabsout, Mounir; Sadek, Salah; Suidan, Makram
Associate Professor: Chehab, Ghassan
Assistant Professors: Abou Najm, Majdi; Abou Zeid, Maya; Alameddine, Ibrahim; El-Khoury, Hiam; Hamzeh, Farook; Hantouche, Elie; Najjar, Shadi; Saad, George; Salam, Darine
Part time Senior Lecturers: Azar, Kamal; Basha, Hisham; Fawwaz, Youssef
Part time Lecturers: El Souri, Amer; Hatem-Moussallem, Manal; Inglessis, Constantine; Nader, Halim; Nasreddine, Khaldoun
Laboratories: El Khatib, Helim

Graduate Programs

Master of Engineering and Master of Science Programs

The Department of Civil and Environmental Engineering (CEE) offers the degrees of Master of Engineering (ME) with the following majors and concentrations:

- **Major: Civil Engineering (CE)**
  - Concentration: Structural, Construction, Geotechnical, Transportation, and Materials
- **Major: Environmental and Water Resources Engineering (EWRE)**
  - Concentration: Environmental and Water Resources

Also offered is a program leading to the degree of Master of Science (MS) in Environmental Science with the following major:

- **Major: Environmental Technology (ET)**

The master's degree programs equip the students with the necessary tools for professional practice and/or the pursuit of higher education.

Doctor of Philosophy Programs

Two programs are offered leading to the Doctor of Philosophy (PhD) degree in Civil and Environmental Engineering with the following specializations:

- **Specialization: Civil Engineering**
  - Concentration: Structural, Construction, Geotechnical, Transportation, and Materials
- **Specialization: Environmental and Water Resources Engineering**
  - Concentration: Environmental and Water Resources

Graduate Catalogue 2014–15
Master of Engineering (ME)

General Information
The Department of Civil and Environmental Engineering offers two graduate programs leading to the ME degree:

• Thesis Program
• Non-Thesis Program

The Thesis Program prepares students through course work and provides them with significant research experience in their selected area of concentration. All graduate students must satisfy either the thesis program requirements or the non-thesis program requirements. The program will be indicated on the student’s transcript.

Admission Requirements
To be eligible for admission to the graduate program a student must hold a bachelor’s degree in Civil Engineering or a related field. Students with a bachelor degree in majors other than in Civil Engineering must fulfill the prerequisite course requirements as set by the department. Students must also satisfy the requirements of the University and the Faculty of Engineering and Architecture for admission to graduate study, as specified in the relevant sections of this catalogue.

Bachelor of Engineering holders from a 5 year equivalent engineering program may obtain a waiver for 9 credits of relevant graduate level courses from their BE degree as long as they maintain an average of 80 on these courses.

Bachelor of Science holders must complete an additional 18 credits of engineering courses prior to enrollment in the Masters program. A minimum grade of 70, or its equivalent, is required in each of these courses. No credit toward the graduate degree is given for these courses.

A minimum of one calendar year of residence is required for graduation. The student must also satisfy all relevant FEA and AUB requirements.

Major: Civil Engineering (CE)

Thesis Program Requirements
In order to fulfill the graduation requirements in the CE Thesis Program, a student must complete a minimum of 24 credit hours of graduate courses and a thesis based on independent research, equivalent to at least six credit hours. The required course work is distributed as follows:

• A minimum of four graduate courses (12 credit hours) in the field of concentration
• A maximum of two graduate courses (6 credit hours) in a relevant CEE field
• A maximum of two graduate courses (6 credit hours) of relevant electives in a related field in engineering or science (Math, Physics, Chemistry, Biology, Geology, Economics)
• Seminar course (CIVE 600)

The courses that fall in the elective category must be pre-approved by the department. Up to two senior undergraduate level civil engineering courses (CIVE 500 series) can be counted towards the Master degree.

Non-Thesis Program Requirements

In order to fulfill the graduation requirements in the Non-Thesis Program a student must complete a minimum of 33 credit hours of graduate courses. The required course work is distributed as follows:

• A minimum of five graduate courses (15 credit hours) in the field of concentration
• A maximum of three graduate courses (9 credit hours) in a relevant CEE field
• A maximum of three graduate courses (9 credit hours) of relevant electives in a related field in engineering or science (Math, Physics, Chemistry, Biology, Geology, Economics)
• Seminar course (CIVE 600)

The courses that fall in the elective category must be pre-approved by the department. Up to three senior undergraduate level civil engineering courses (CIVE 500 series) can be counted towards the Master degree.

Major: Environmental and Water Resources Engineering (EWRE)

Thesis Program Requirements

In order to fulfill the graduation requirements in the CE Thesis Program, a student must complete a minimum of 24 credit hours of graduate courses and a thesis based on independent research, equivalent to at least six credit hours. The required course work is distributed as follows:

• A minimum of two core graduate courses (6 credit hours) in the area of specialty
• A minimum of two graduate elective courses (6 credit hours) in the area of specialty
• A minimum of two graduate courses (6 credit hours) in the minor area
• A maximum of one graduate elective course (3 credit hours) in a related field in engineering or science (Math, Physics, Chemistry, Biology, Geology, Economics)
• Experimental Design and Statistical Methods course (3 credit hours) (CIVE 602)
• Seminar course (CIVE 601)

The courses that fall in the elective category must be pre-approved by the department. Up to two senior undergraduate level civil engineering courses (CIVE 500 series) can be counted towards the Master degree.
Non-Thesis Program Requirements

In order to fulfill the graduation requirements in the Non-Thesis Program a student must complete a minimum of 33 credit hours of graduate courses. The required course work is distributed as follows:

- A minimum of two core graduate courses (6 credit hours) in the area of specialty
- A minimum of three graduate elective courses (9 credit hours) in the area of specialty
- A minimum of three graduate courses (9 credit hours) in the minor area
- A maximum of two graduate elective courses (6 credit hours) in a related field in engineering or science (Math, Physics, Chemistry, Biology, Geology, Economics)
- Experimental Design and Statistical Methods course (3 credit hours) (CIVE 602)
- Seminar course (CIVE 601)

The courses that fall in the elective category must be pre-approved by the department. Up to three senior undergraduate level civil engineering courses (CIVE 500 series) can be counted towards the Master degree.

Specialization: Environmental Engineering

Minor: Water Resources Engineering

- Core Courses:
  - CIVE 550, CIVE 551, CIVE 552, CIVE 553, CIVE 555
- Elective Courses:
  - CIVE 645, CIVE 650, CIVE 651, CIVE 652, CIVE 653, CIVE 654, CIVE 655, CIVE 656, CIVE 657, CIVE 751, CIVE 752, CIVE 755, CIVE 756

Specialization: Water Resources Engineering

Minor: Environmental Engineering

- Core Courses:
  - CIVE 541, CIVE 542, CIVE 640, CIVE 641, CIVE 642
- Elective Courses:
  - CIVE 644, CIVE 645, CIVE 647, CIVE 648, CIVE 649, CIVE 656, CIVE 740, CIVE 756

Master of Science (MS)

Major: Environmental Technology (ET)

The Department of Civil and Environmental Engineering offers a graduate program leading to the degree of Master of Science in Environmental Technology (ET). The program is part of the Interfaculty Graduate Environmental Sciences Program (IGESP) and it is open to non-engineering students who hold a degree in basic sciences. For more details on IGESP program refer to the Interdisciplinary Research Centers and Programs section of this catalogue.

For more details on IGESP program refer to the Interdisciplinary Research Centers and Programs section of this catalogue.
In order to fulfill the graduation requirements in the MS Program, a student must complete a minimum of 24 credit hours of graduate courses and a thesis equivalent to six credit hours, or 27 credit hours of graduate courses and a project course equivalent to three credit hours.

The required course work is distributed as follows:

- A minimum of two core mandatory courses (6 cr.) (ENSC 630, ENSC 640, ENSC 650)
- A minimum of three graduate core courses (9 cr.) in Environmental Engineering
- A minimum of two graduate elective courses (6 cr.) in Environmental Engineering
- Experimental Design and Statistical Methods course (3 cr.) (CIVE 602)
- Seminar course (CIVE 601)

**Doctor of Philosophy (PhD)**

**General Information**

The PhD programs offered by the CEE department train the graduate students to address and solve current problems in civil and environmental engineering. PhD students are trained to be future educators and proficient researchers geared to assume leadership roles in their profession.

The objectives of the PhD program are to:

- Cultivate expertise in concentration areas of Civil and Environmental Engineering
- Develop research skills necessary for the formulation and solution of challenging problems
- Acquire teaching expertise through assistance in class lectures and laboratory sessions.

**Admission Requirements**

To be eligible for admission to the PhD program, a candidate must:

- hold a master’s degree in Civil and Environmental Engineering or a related discipline from AUB or another recognized institution of higher learning with a minimum cumulative average of 85 over 100 (for admission in the regular track), or a Bachelor’s degree in Civil Engineering or a related discipline (for admission in the accelerated track)
- submit a complete application including a statement of interest, transcripts of academic record from all institutions attended after high school, a curriculum vita, and three letters of recommendation
- provide scores for the General Exam part of the Graduate Record Examination (GRE)
- must show proficiency in the English language in case English is not the native language (refer to the catalogue section on English Language Proficiency Requirement)
- complete an interview either in person or by phone (for non-AUB students)

The application to the doctoral program will follow the deadlines set by the Office of Admissions at AUB. Admission decision for the PhD program is made upon the recommendations of the CEE department and the FEA Graduate Studies Committee, with the approval of the AUB Board of Graduate Studies.
Regular PhD Program Requirements
The regular PhD program requires a minimum of 24 credit hours of course work beyond the master’s degree and 24 credit hours of thesis work. The course work consists of
• a minimum of 12 credits in the area of concentration,
• 6 credits in a related area, and
• 6 credits in an area other than the candidate’s field of research, which can be taken inside or outside the department

Accelerated PhD Program Requirements
The accelerated PhD program requires a minimum of 36 credit hours of course work beyond the bachelor’s degree and 42 credit hours of thesis work. The course work consists of
• a minimum of 21 credits in the area of concentration,
• 9 credits in a related area, and
• 6 credits in an area other than the candidate’s field of research, which can be taken inside or outside the department

Candidacy Requirements
Qualifying Exam Part I: Comprehensive Exam
All students admitted to the PhD program must successfully complete a written comprehensive examination administered by the department. The purpose of the comprehensive exam is to ascertain the student’s knowledge in his/her field of specialization and related areas. The written exam will cover major topics from within the concentration area and related fields. Normally, a student on the regular track will take the comprehensive exam not later than 18 months after enrollment in the PhD program and after completing a minimum of 18 credits of courses. Normally, a student on the accelerated track will take the comprehensive exam no later than 24 months after enrollment in the PhD program and after completing a minimum of 27 credits of courses. Students who do not pass the comprehensive exam may, upon the recommendation of the department, take it for a second time in the following semester. Failure on the second attempt will result in the student’s discontinuation from the graduate program.

Qualifying Exam Part II: PhD Thesis Defense
All students must successfully complete a qualifying examination, which is to be taken at least two semesters prior to the final defense of the PhD thesis. The qualifying exam, administered by the thesis committee is an oral exam in which the student presents his/her research proposal. This proposal should include the projected research methodology and anticipated outcomes, as well as the preliminary results. The objective of the oral exam is to determine whether the candidate’s proposal and methodology are adequate for a PhD thesis. The candidate must show positive preliminary results and considerable promise of original research. It is the responsibility of the student to inform and update the thesis committee members about his/her research progress, especially during the period between the comprehensive and qualifying exams. Students who do not pass the qualifying exam may, upon the recommendation of the department, take it for a second time in the following semester. Failure on the second attempt will result in the student’s discontinuation from the graduate program.
Admission to Candidacy

Students enrolled in the program must be admitted to candidacy at least two semesters prior to the expected date of graduation. To be eligible for candidacy, students must:

• Pass the qualifying exams (Part I and Part II), and
• Complete at least 24 credits of course work on the regular track and 36 credits of course work on the accelerated track with a minimum cumulative grade average of 85.

Thesis Requirements

In partial fulfillment of the requirements for the degree of doctor of philosophy, a student must submit a thesis that is expected to make a significant and original contribution to his/her field of research. The research work is to be carried out under the supervision of a full-time faculty member from the Civil and Environmental Engineering department.

Thesis Committee

The thesis work will be supervised by a committee of at least five members. One of the committee members should be from outside the department/program and two from outside the university. All members of the committee must hold a doctoral degree in a relevant field and be of professorial rank. The chair of the committee must hold the rank of a full professor and must not be the PhD thesis adviser. The doctoral thesis committee approves the thesis topic and research plan, and conducts the PhD proposal defense and the PhD thesis defense.

Thesis Defense

All PhD candidates must defend their thesis in public. The candidate will be examined by the thesis defense committee chaired by one of the members of the thesis committee other than the thesis adviser. A grade of pass or fail will be reported for the PhD thesis. If a grade of fail is reported, the student may resubmit the thesis and defend it after a period of at least four months. Failure on the second attempt will result in the student’s discontinuation from the program.

PhD Publication Requirements

See PhD Publications Requirements, under General University Academy Information.

Residence Requirements

To satisfy the minimum residence requirements for the PhD degree, all students must register and be in residence for at least three years beyond the completion of the master’s degree. To satisfy the minimum residency requirements for the PhD degree in the accelerated PhD program, all students must register for at least eight semesters beyond the completion of the bachelor’s degree. The requirements for the degree of doctor of philosophy must be completed within a period of six years after joining the PhD program. Extension beyond the six-year period will require the approval of the Faculty Graduate Studies Committee and the Graduate Council.
Graduation Requirements

To earn a PhD degree in the Department of Civil and Environmental Engineering, a student must fulfill the following graduation requirements:

- Attain a minimum cumulative average of 85 in 24 credits (regular program) or 36 credits (accelerated program) of course work taken at the PhD level;
- Attain a minimum grade of 75 for courses taken at the PhD level;
- Pass the PhD thesis defense;
- Satisfy the minimum residency requirements;
- Have at least two accepted refereed journal papers, based on the PhD research;
- Satisfy all pertinent AUB regulations.

Sample Study Program

A typical program of study for a PhD student is shown below.

<table>
<thead>
<tr>
<th>Year</th>
<th>Semester</th>
<th>Course</th>
<th>Credits</th>
<th>Total</th>
<th>Timeline</th>
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<td>Spring</td>
<td>Thesis</td>
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<td>48</td>
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</table>

A typical program of study for an accelerated PhD student is shown below.

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<th>Course</th>
<th>Credits</th>
<th>Total</th>
<th>Timeline</th>
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<td>Summer</td>
<td>Thesis</td>
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<td>Fall</td>
<td>Major course</td>
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<td>Major course</td>
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</tbody>
</table>
PhD in Civil Engineering (CE)

The concentration areas and specialized tracks of the PhD programs in CE are consistent with the fields of expertise and research interests of the faculty members, and the existing research and laboratory facilities. The specialty areas are as follows:

### Structural and Materials Engineering
- Advanced design and behavior of concrete, steel structures, and fiber-reinforced composites
- Strengthening and rehabilitation of structural systems; and structural health monitoring
- Advanced concrete technology including plain, hot-weathered, and high-strength concrete
- Petrographic, chemical, and mechanical properties of sands and aggregates
- Seismic evaluation and assessment, and earthquake engineering design
- Numerical modeling and computer-aided structural engineering

### Construction Engineering
- Lean construction and productivity improvement in construction
- Building information modeling and knowledge management
- Applications of innovative sensing approaches and information technology to construction
- Construction processes and methods
- Life cycle cost analysis and value engineering for construction projects
- Sustainable construction
- Infrastructure health monitoring
- Procurement and supply chain management in construction

### Geotechnical Engineering
- Land reclamation and site improvement
- Geographic Information Systems (GIS) used in decision making and expert tool applications
- Geo-environmental engineering with reference to waste disposal and site contamination
- Geotechnical earthquake engineering, geo-hazards and risk assessment
- Behavior of soils

### Transportation Systems
- Urban transportation planning and modeling (Transport and mobility considerations in urban universities; Characterization of uncontrolled traffic conditions and walkability in urban areas; Travel demand modeling)
• Public transport (Operational planning and market arrangement implications in mass transit systems)
• Transportation and the environment (Modeling and estimation of traffic induced emissions)
• Road safety (Modeling and simulation of aggressive driver behavior)
• Maritime transport (Maritime shipping; Optimization of container terminal operations)
• Project evaluation (Feasibility assessment and project delivery of transport infrastructure projects)

PhD in Environmental and Water Resources Engineering (EWRE)

The PhD program in EWRE focuses on the following courses and research topics:
• Water and wastewater treatment systems
• Solid and industrial waste treatment/management
• Air quality management and air pollution control
• Environmental and water resources management and planning
• Water Quality Modeling
• GIS and IT applications for environmental and water resources management
• Watershed modeling and management
• Hydrologic systems analysis
• Hydraulic systems analysis

PhD Publication Requirements:
See PhD Publication Requirements, under General University Academic Information.

Course Descriptions

Common Courses

**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. *Prerequisites: EECE 231.*

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

**CIVE 600 B 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 Systems (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 Methods  3 cr.  A course that covers the main steps required to efficiently plan, conduct, analyze, and interpret the results from experiment 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 Courses

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; 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 410.

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 prestressed 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. 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 410 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.
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 Hook’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.

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.

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.

Construction Courses

CIVE 521  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, operating costs, and safety management. Prerequisite: CIVE 370.

CIVE 522  Building Construction and Estimating  3 cr.
A course that exposes students to building systems and how to integrate them by choosing the best materials and methods (concrete, masonry, steel, thermal and moisture protection, mechanical and electrical, etc. The presentation of professional construction documents including execution drawings, details, and specifications will also be covered.

CIVE 523  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 620  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 621  Infrastructure Construction and Rehabilitation  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; as well as their applications to urban and rural areas, while focusing on QA/QC, environment, and safety.
CIVE 622  Advanced Construction Scheduling  3 cr.
A course that provides advanced techniques in construction scheduling. It examines monitoring, updating, and controlling the project schedule; impact of scheduling on productivity PERT techniques, operational planning and scheduling, and use of scheduling software (primavera). Prerequisite: CIVE 523

CIVE 623  IT Applications in Construction  3 cr.
A course that covers computing tools impacting the construction industry such as mobile computing and information systems to support field engineering tasks; computerized systems applications to perform specific functions, such as estimating, scheduling, cost control; emerging sensing and instrumentation technologies to solve construction problems and case studies.

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  Construction Business Management  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, accounting, financing, risk analysis, and quality; and the principles and sources of construction funding for contracting firms and projects.

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 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.

CIVE 628  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 629  Construction Decisions under Uncertainty  3 cr.
A course that covers construction project and organization decisions for the uncertain future. The selection of construction method, equipment, contract, markup, and financing alternatives having the highest expected values; uses decision theory, competitive bid analysis, probabilistic modeling and simulation, and multiple regression analysis in managing construction.

CIVE 720  Advanced Construction Safety  3 cr.
A course that exposes students to the real world of construction and the complexity of managing machines, material and people. The course content includes the selection of construction equipment and material based on applications, methods, and production requirements for earthmoving, heavy and building construction.

CIVE 721  Legal Aspects of Construction  3 cr.
A course that covers legal problems and liability issues in the area of construction contracts, torts, and insurance.
CIVE 722  Sustainable Design and Construction  3 cr.
A course that covers principles of sustainable design and construction, including life-cycle cost analysis, evaluation of economic and environmental impacts, state-of-the-art technology.

Geotechnical Courses

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 conditions, undrained, 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; evaluation and mitigation of soil liquefaction; seismic code provisions and additional current topics. Prerequisite: CIVE 430.

Water Resources Courses

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, 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, 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 and 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 socio-economic 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 Courses

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 designed to teach students the scientific and engineering principles of microbiological
treatment technologies to clean contaminated environments and formulate effective solutions
to problems in biochemical engineering. **Prerequisite: CIVE 251, 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. **Prerequisites: CIVE 550 and 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.
**Prerequisite: CIVE 251, 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: 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 micro-
organisms; energy, metabolism, and synthesis; growth, decay, and kinetics; and biological
water quality indicators. **Prerequisites: CIVE 251, 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.

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: E4 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, 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, and properties. Impacts and auditing of industrial facilities. Basic treatment processes and disposal methods. Site remediation. Prerequisite: 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 opponents’ perspective and 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 Courses

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. Prerequisites: CIVE 460, 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. Prerequisites: CIVE 460, 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, 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. Prerequisites: CIVE 460, 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 flows; hydrodynamic analogue; and computer simulation models. Prerequisite: CIVE 460.

Materials Courses

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 covers viscoelastic behavior of construction materials, particularly asphalt concrete and polymer composites. The course deals with basic concepts in material characterization, rheology, time-temperature superposition principles, linear and nonlinear viscoelastic models.

Multidisciplinary Courses

CIVE 681 Evaluation of Cost Alternatives 3 cr.
A course that covers the basic principles of economic evaluations using fundamental concepts of time value of money to compare cost 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.**

### 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.
CIVE 799  ME/MS Thesis  6 cr.
CIVE 980  Qualifying Exam I: Comprehensive Exam  0 cr.
CIVE 981  Qualifying Exam II: Thesis Proposal Defense  0 cr.
CIVE 982  PhD Thesis  3 cr.
CIVE 983  PhD Thesis  6 cr.
CIVE 984  PhD Thesis  9 cr.
CIVE 985  PhD Thesis  12 cr.
CIVE 986  PhD Thesis  0 cr.
CIVE 989  PhD Thesis Defense  0 cr.