DEPARTMENT OF CIVIL ENGINEERING
MASTER OF SCIENCE (MS) DEGREE
(5 Electives will define a Track)

FOURTH YEAR
Semester 7

Course Code	Course Title	Credit
CIVE 401	Theory of Structures II	3
CIVE 403	Deep Foundations	3
CIVE 424	Advanced Mechanics of Materials for Civil Engineering	3
	Elective	3
	Elective	3
Total		**15**

FOURTH YEAR
Semester 8

Course Code	Course Title	Credit
CIVE 402	Dynamics of Structures I	3
GENG 450	Advanced Engineering Analysis and Research Methodology	3
GENG 402	Project Management	3
GENG 590	Master Project	3
LISP 400	Master Thesis/Project Seminar	1
	Elective	3
Total		**16**

FOURTH YEAR

Semester 9 (Summer)		Credit
Course Code	**Course Title**	
GENG 480	Field Training	3
Total		**3**

FIFTH YEAR
Semester 10

Course Code	Course Title	Credit
CIVE 405	Prestressed Concrete	3
CIVE 503	Highway Design	3
GENG 400	Engineering Seminars	1
GENG 590	Master Project (Re-activation)	0
	Elective	3
	Elective	3
Total		**13**

Total credits **47**

Elective Courses (15 Credits from the following Tracks list):

(*) Structural Track

Course Code	Course Title	Credit
CIVE 411	Introduction to Earthquake Engineering and Seismology	3
CIVE 443 *	Seismic Design of Reinforced Concrete Buildings	3
CIVE 444	Seismic Design of Foundations	3
CIVE 502	Theory of Elasticity	3
CIVE 504	Finite Element Analysis	3
CIVE 505	Dynamics of Structures II	3
CIVE 506	Stability of Structures	3
CIVE 555	Special Topics in Civil Engineering	3
CIVE 556	Bridge Design	3
CIVE 557	Advanced Structural Steel Design	3
CIVE 561	Retaining Structures Design	3
CIVE 562	Design of Timber Structures	3
CIVE 566	Theory of Plates and Shells	3
	* Directed Elective	

(*) Transportation Track

Course Code	Course Title	Credit
CIVE 404	Hydraulics	3
CIVE 456	Fundamentals of Road Construction	3
CIVE 507	Boundary Surveys	3
CIVE 512	Pavement Design	3
CIVE 513	Traffic Engineering	3
CIVE 556	Bridge Design	3
CIVE 559	Pavement Reconstruction, Rehabilitation and Maintenance	3
CIVE 560	Transportation Management Systems	3

(*) Environmental Track

Course Code	Course Title	Credit
CIVE 418	Sewage Treatment Plant	3
CIVE 419	Recycling of Sewage Treatment End-Products	3
CIVE 438	Green Buildings and Sustainability	3
CIVE 520	Principles of Environmental Engineering	3
CIVE 521	Wastewater Engineering Design	3
CIVE 522	Water Resources and Water Quality	3
CIVE 523	Air Pollution Control	3
CIVE 524	Solid Waste Disposal	3
CIVE 525	Sanitary Landfill	3
CIVE 526	Water Supply Engineering Design	3
CIVE 527	Environmental Impact Assessment	3
CIVE 528	Environmental Economics and Management	3
CIVE 529	Environmental Chemistry	3
CIVE 530	Environmental Chemistry and Microbiology	3
CIVE 531	Environmental Sampling and Analysis	3
CIVE 532	Wastewater Treatment Plants: Processes, Design, and Operation	3
ENVE XXX	Pre-approved by the Civil Engineering Department	3

(*) Geotechnical Track

Course Code	Course Title	Credit
CIVE 411	Introduction to Earthquake Engineering and Seismology	3
CIVE 433	Earthquake Geotechnical Engineering	3
CIVE 443	Seismic Design of Reinforced Concrete Buildings	3
CIVE 444	Seismic Design of Foundations	3
CIVE 558	Seepage, Embankment and Slope Stability	3
CIVE 561	Retaining Structures Design	3
CIVE 563	Advanced Soil Mechanics	3
CIVE 564	Geosynthetics	3
CIVE 565	Soil-Structure Interaction	3

(*) Management Track

Course Code	Course Title	Credit
CIVE 420	Construction Processes	3
CIVE 422	Simulation of Construction Operations	3
CIVE 426	Building Construction Methods	3
CIVE 427	Construction Cost Management	3
CIVE 428	Construction Safety Management	3
CIVE 429	Construction Contracts Management	3
CIVE 430	Construction Equipment Management	3
CIVE 431	Civil Infrastructure Management	3
CIVE 560	Transportation Management Systems	3
CIVE 568	Management of Civil Engineering Systems	3
ENMG XXX	Pre-approved by the Civil Engineering Department	3

(*) Water Resources Track

Course Code	Course Title	Credit
CIVE 404	Hydraulics	3
CIVE 409	Hydrology	3
CIVE 410	Applied Hydraulics	3
CIVE 425	Principles of Hydrogeology	3
CIVE 558	Seepage, Embankment and Slope Stability	3

(*) Earthquake Engineering Track

Course Code	Course Title	Credit
CIVE 411	Introduction to Earthquake Engineering and Seismology	3
CIVE 414	Earthquake Loss Estimations	3
CIVE 421	Seismic Design of Structures: Displacement Based	3
CIVE 423	Assessment and Strengthening of Structures	3
CIVE 433	Earthquake Geotechnical Engineering	3
CIVE 436	Earthquake Design according to the IBC Code and Euro code EC8	3
CIVE 443*	Seismic Design of Reinforced Concrete Buildings	3
CIVE 444	Seismic Design of Foundations	3
CIVE 505	Dynamics of Structures II	3
CIVE 557	Advanced Structural Steel Design	3

* Directed Elective

(*) Ocean Engineering Track

Course Code	Course Title	Credit
CIVE 404	Hydraulics	3
CIVE 508	Ocean Engineering	3
CIVE 509	Mechanics of Water Waves	3
CIVE 510	Modeling of Coastal Engineering Problems	3
CIVE 511	Coastal and Platform Design	3

(*) Materials Track

Course Code	Course Title	Credit
CIVE 432	Concrete Technology	3
CIVE 451	Concrete Durability	3
CIVE 452	Cement Manufacturing and Hydration	3
CIVE 453	Concrete Materials for Sustainable Development	3
CIVE 454	Concrete Testing and Repair	3
CIVE 456	Fundamentals of Road Construction	3
CIVE 567	Physical Metallurgy of Steel	3

N.B. Student may choose Thesis Option GENG 599, 6 cr. This option will replace GENG 590 and one Elective.

COURSE DESCRIPTIONS

CIVE 401 THEORY OF STRUCTURES II (3.0: 3 cr. E)
Approximate analysis of continuous beams, and frames. Parametric studies of some basic structures including towers, buildings and bridges. Estimating deflections. Analysis of beam, truss, and frame structures using the unit load method and the direct stiffness method. Influence lines of determinate and indeterminate continuous beams.

CIVE 402 DYNAMICS OF STRUCTURES I (3.0: 3 cr. E)
Introduction to basics of dynamics: lumped mass dynamics with various loading functions. Response to general dynamic loading with and without damping; free vibration, harmonic, impulsive, and arbitrary excitations. Develop the dynamic equations of motion for the single degree of freedom system (SDF) and multi-degree of freedom systems (MDF). Response spectrum analysis. Modal analysis of linear systems.
Pre-requisite: CIVE 401

CIVE 403 DEEP FOUNDATIONS (3.0: 3 cr. E)
Fundamentals of geotechnics applied to design and analysis of deep soil – structure systems; single pile, pile groups under axial load; sheet piles, tiebacks, caissons and piers; effect of lateral loads; efficiency of group pile, settlement of pile, braced cut, reinforced earth structure; computer software implementation.

CIVE 404 HYDRAULICS (3.0: 3 cr. E)
The course consists of the design and analysis of water supply networks including transmission and distribution pipes, reservoirs, tanks, pumps and pump selection, using the conservation of mass, momentum, and energy equations; design and analysis of open channels including gradually varied flows, backwater computations, and water surface profiles using the Manning equation; design and analysis of box culverts with inlet and outlet control.

CIVE 405 PRESTRESSED CONCRETE (3.0: 3 cr. E)
Fundamentals of Pre-stressed concrete behavior. Analysis and design of pre-tensioned and post tensioned reinforced concrete members. Prestressed concrete is used to construct light, durable, and economical structures by pre-compressing the concrete that has high compressive strength using high strength pre-stressing steel. Preloading the tensile zone of the structural concrete members results in a self-equilibrating system of internal stresses under expected loads.

CIVE 409 HYDROLOGY (3.0: 3 cr. E)
The course consists of describing the hydrologic cycle, precipitation and the water budget equation, interception and depression storage, infiltration, evaporation, transpiration, stream flow, groundwater, probability and statistics with frequency of occurrence, hydrographs, routing, with hydrologic modeling.

CIVE 410 APPLIED HYDRAULICS (3.0: 3 cr. E)
The course consists of describing the complete design and construction process of storm water networks including ponds, sewerage networks, water supply networks, irrigation networks, box culverts, open ditches, and scour analysis for bridges over waterways, and understanding of the Navier-Stokes equations.
Pre-requisite: CIVE 404
Co-requisite: CIVE 409

CIVE 411 INTRODUCTION TO EARTHQUAKE ENGINEERING & SEISMOLOGY (3.0: 3 cr. E)
Earthquake engineering, deals with the effects of earthquakes on people and their environment and with methods reducing those effects. This course is designed to help understand the fundamental principles and practical methods of earthquake engineering. It introduces the basic concepts of seismology, earthquakes, and strong ground motion and introduces procedures of deterministic and probabilistic seismic hazard analysis.

CIVE 414 EARTHQUAKE LOSS ESTIMATIONS (3.0: 3 cr. E)
In the last few decades, a dramatic increase in the losses caused by natural catastrophes has been observed worldwide. The reasons for the increased losses are manifold, though certainly include the increase of world population, the development of new “super-cities” (with population greater than 2 millions), many of which are located in zones of high seismic hazard, and the high vulnerability of modern societies and technologies, such as the built environment. This course deals with the treatment of exposure, hazard, and vulnerability in earthquake loss models for urban areas and the propagation of the uncertainties within such models. Various case study applications involving the state-of-the art in catastrophe loss assessment will be presented.

CIVE 418 SEWAGE TREATMENT PLANT - DESIGN OF THE SYSTEM AND BASICS OF THE PROCESS (3.0: 3 cr. E)
The course explores the fundamentals of the physical and biochemical activities that set up the treatment process, and the biotechnology involved in the design and functioning of the treatment plant. It studies the physical laws of sedimentation and flotation, the biochemical principles of degradation of waste organics, fate of potentially hazardous industrial pollutants, mobilization\immobilization of nutrients, and properties of the final effluent and sludge. The course exposes students to a wide spectrum of available technologies for the design of treatment plants, technical success, low construction and operational costs, good quality effluents, and choice of treatment level VIS-À-VIS reuse.

CIVE 419 RECYCLING OF SEWAGE TREATMENT END-PRODUCTS (3.0: 3 cr. E)

The course examines the cons and pros of the reuse of treated sewage in industry and on-land. It looks into the analysis of the effluent and sludge, and the impact of its application on plant nutrition, and on the physical, chemical and microbiological status of the soil system. It covers topics like the soil conditioning effect of sludge and its impact on soil-water-plant relationship; the possible contamination of food chain with potentially hazardous chemicals; biogas production from and composting of sludge; design of the systems employed in recycling; and the management of these practices in safe and environmentally sound manners.

CIVE 420 CONSTRUCTION PROCESSES (3.0: 3 cr. E)
This course provides an overview of various construction processes. It focuses on several specific construction methods and engineering fundamentals of underground and aboveground construction, especially earthmoving operations. It focuses on the earthmoving operations' equipment: shovels, backhoes, clamshells, draglines, loaders, dozers scrapers and compactors. Course concentrates on the productivity evaluation of the construction processes, both deterministic, and using the queuing theory.

CIVE 421 SEISMIC DESIGN OF STRUCTURES: DISPLACEMENT BASED (3.0: 3 cr. E)
The approach is based on determination of the optimum structural strength to achieve a given performance limit state, related to a defined level of damage, under a specific level of seismic intensity. Fundamental of displacement based design, seismic input for displacement based design, analytical tools for displacement based design. The course considers a wide range of structural types, including among other; frame buildings, wall buildings, dual wall / frame buildings.

CIVE 422 SIMULATION OF CONSTRUCTION OPERATIONS (3.0: 3 cr. E)
This course provides an overview of the quantitative stochastic methods used for the design and analysis of construction operations, in order to maximize the productivity and resource utilization through discrete event simulation. The course provides an introduction to queuing theory, and then focuses on simulation for construction operation analysis. Specific emphasis is placed on modeling building construction, heavy and highway construction, and underground construction technologies. Micro-CYCLONE simulation languages are used for the design of the construction operations.

CIVE 423 ASSESSMENT & STRENGTHENING OF STRUCTURES (3.0: 3 cr. E)
Assessment of seismic vulnerability of classes of buildings: force-based and displacement-based methodologies. Typical response of individual buildings: capacity design concepts, analysis of well-designed buildings. Typical response of existing buildings: problems in analysis, damage and safety evaluation. Strength, deformation and dissipation capacity of elements and joints: flexural and shear problems, beam-column joints, infill panels. Assessment of global response: expected damage and failure modes, global strength, deformation and dissipation capacity, displacement based assessment methods. Strengthening of reinforced concrete buildings: modification of element and global response, redesign, safety re-evaluation.

CIVE 424 ADVANCED MECHANICS OF MATERIALS FOR CIVIL ENGINEERING (3.0: 3 cr. E)
Concept of tensors of various degrees and dimensions using dyadics and the transformation of their components. Review of Mohr circle. Strain tensor, its properties and strain-displacement relations. Traction, stress tensor, their properties and stress equilibrium equations. Stress-strain relations for linear elastic materials and the role of symmetry. Overall formulation of small strain linear elasticity. Plane stress and plane strain with example solutions. Stress concentrations. Principle of virtual work and other derived, specialized principles. Torsion of non-circular cross-sections. Unsymmetrical bending. Stresses in thin-walled axisymmetric pressure vessels.

CIVE 425 PRINCIPLES OF HYDROGEOLOGY (3.0: 3 cr. E)

Hydrology and modeling : porosity, hydraulic conductivity, permeability, specific yield, transmissivity, storativity, karst spring, spring hydrographs, methods of analysis and well location, design and construction, pumping tests, testing in fractured rocks: constant head, pumping tests, pulse interference tests, tracer testing, salt water intrusion, groundwater modeling with Modflow.

CIVE 426 BUILDING CONSTRUCTION METHODS (3.0: 3 cr. E)
New Construction methods in tunneling, excavations and buildings. Immersed, cut & cover, top down methods of tunneling construction. Tunnel boring, trenchless technology, vibroflotation, jet grouting & deep water drilling are explained. Different building methods are reviewed: underpinning of foundations, earthquake resisting systems & components, new & existing formwork technologies, tilt-up wall & lift slab construction, pneumatic wedge method of concrete dome construction, volumetric construction, 3-D printing of concrete & steel, tremie concrete & underwater construction, concrete canvas, foamcrete, thin joint mortar types, polyurea, smart bricks, rammed earth, drones & robots in construction, insulated concrete forms block, cellular light concrete block and other block types.

CIVE 427 CONSTRUCTION COST MANAGEMENT (3.0: 3 cr. E)
This course focuses on (i) estimating different costs of projects, (ii) perform life cycle cost analysis for projects, study the different financing methods for both owners and contractors, (iv) understand cost control and monitoring of budgets, and (v) how to include costs in different contract types.

CIVE 428 CONSTRUCTION SAFETY MANAGEMENT (3.0: 3 cr. E)
Identification of hazards and risks on construction sites; hazard evaluation; hazard control; fault tree analysis; crane, equipment, universal, access, construction, operation and maintenance hazards; and safety measures applications.

CIVE 429 CONSTRUCTION CONTRACTS MANAGEMENT (3.0: 3 cr. E)
Types of construction contracts; types of project delivery systems; different contract administration; contract accounting; and claims and disputes.

CIVE 430 CONSTRUCTION EQUIPMENT MANAGEMENT (3.0: 3 cr. E)
The aim of this course is to train students in types of construction equipment management, mainly machine power estimation; equipment selection and utilization; equipment costs; and life cycle costs of equipment.

CIVE 431 CIVIL INFRASTRUCTURE MANAGEMENT (3.0: 3 cr. E)
This course provides an overview of various civil infrastructure. It focuses on the main categories of civil infrastructure; condition assessment of different infrastructure (pipes, sewers, buildings, bridges, transit); deterioration methodologies (regression, Markov Chain, reliability); rehabilitation methods; optimization of maintenance; and budget allocation.

CIVE 432 CONCRETE TECHNOLOGY (3.0: 3 cr. E)
Concrete components. Cementitious materials and chemical admixtures and their role in modifying concrete properties. Hot weather and cold weather concreting. High-performance concrete. Virtual cement and concrete testing laboratory. 3D concrete printing. A research project that gives students a wider exposure to Concrete Technology through their internet search is required.

CIVE 433 EARTHQUAKE GEOTECHNICAL ENGINEERING (3.0: 3 cr. E)
The practice of geotechnical earthquake engineering principally involves the application of seismic analysis methodologies in the design and assessment of geotechnical structures. Analysis methodologies focus primarily on evaluation of site response and possible occurrence of liquefaction in modifying the seismic hazard at a site, and the consequences on the design of geotechnical

structures such as shallow and deep foundations, slopes, embankments and earth retaining structures. The behavior of these structures under dynamic loading is also performed using the finite element software PLAXIS 2D.

CIVE 436 EARTHQUAKE DESIGN ACCORDING TO THE IBC CODE AND EUROCODE EC8 (3.0: 3 cr. E)

This course allows the students to design structures following the most recent codes in the United States known as the International Building Code (IBC) and in Europe known as the Euro code EC8.

CIVE 437 EXPERIMENTAL METHODS IN EARTHQUAKE ENGINEERING (3.0: 3 cr. E)

In modern structural engineering the exposure to experimental activity is unavoidable. The use of current materials and technologies, as well as the curiosity toward future solutions, requires a solid base of understanding of performance, obtained through experiments. The course will introduce the students to the theory and practice of laboratory activities typical of the research effort in earthquake engineering. Particular emphasis will be dedicated to the need for a correct balance in every phase of the experimental process, from general planning to analysis of results. A series of tests will be designed, "virtually" performed and critically analyzed using existing data from large scale tests of reinforced concrete specimens. A dedicated session will introduce the typical experimental activity on innovative anti-seismic devices**.**

CIVE 438 GREEN BUILDINGS AND SUSTAINABILITY (3.0: 3 cr. E)

This course addresses the sustainability principles applied to site planning, building design, construction, operation, and management. It combines elements from various engineering disciplines and addresses the emerging trends in Leadership in Energy and Environmental Design (LEED) certification by US Green Building Council (USGBC).

CIVE 439 STRONG MOTION SEISMOLOGY (3.0: 3 cr. E)

The focus is given to ground motion recorded near the earthquake source. The relation between the ground motions (from a point source, and a finite fault) and the dynamics of faulting is described. The covered topics are the parameters of a spectral model of an earthquake such as stress drop, seismic moment and corner frequency, directivity effects due to rupture velocity, polarization of ground motion, and spatial variation from radiation pattern effects, isochrones, attenuation and site amplification due to local structure.

CIVE 440 GEOPHYSICAL DATA ANALYSIS (3.0: 3 cr. E)

The course helps the students to understand the principles of digital signal processing, filter theory and the application of spectral methods in the analysis of geophysical data. Topics include discrete Fourier transforms, convolution, power spectra, coherence, transfer functions, covariance, correlation, Laplace transforms, Z-transforms, filters, deconvolution, auto-regressive models, spectral estimation, basic statistics, 1-D wavelets, model fitting via singular valued decomposition.

CIVE 441 VIBRATION CONTROL (SEISMIC ISOLATION/ADDED DAMPING) (3.0: 3 cr. E)

The main objective of this course is to introduce structural engineers to the basic principles of passive supplemental damping and seismic isolation systems and to their implementation into real structures for enhanced seismic protection. An introduction on the basic earthquake engineering principles and energy formulation needed to understand the impact of different supplemental damping and isolation techniques on the performance of structures is first provided. The focus is then set on theoretical and applied knowledge on various supplemental damping and seismic isolation systems that have demonstrated potential at raising the performance of buildings and bridges under earthquake ground motions while keeping construction costs reasonable. The course will cover hysteretic dampers, viscous and visco – elastic dampers, self-centering systems, tuned-mass dampers, elastomeric, lead-

rubber, metallic and sliding bearings and will present their physical behavior, analytical modelling, experimental investigations and practical implementations. Design strategies and methods are also presented for each of the supplemental damping and seismic isolation systems.

CIVE 442 DECISION AND RISK MANAGEMENT (3.0:3 cr. E)
This course introduces Multi-Criteria Decision methods, such as Multi-Attribute Utility Theory, the Analytic Hierarchy Process and TOPSIS; in addition to outranking methods such as PROMETHEE II. The course also introduces weights evaluation such as swinging weight method and point allocation method. The course introduces group decision making techniques and sensitivity analysis. Then, the course introduces decision under uncertainty, mainly decision matrices, maxima, maximin and hurwicz methods. Also, it introduces the decision tree method using expected values and utilities. Finally, the course explains risk management, and the tools applied in order to identify, evaluate and mitigate risk. The course introduces the qualitative and quantitative analysis using Monte Carlo simulation of risk in projects, mainly, in schedules and cost estimates.

CIVE 443 SEISMIC DESIGN OF REINFORCED CONCRETE BUILDINGS (3.0: 3 cr. E)
Basic seismology, earthquake characteristics and effect of earthquakes on structures. Seismic base shear calculation using the (IBC-2012) and (UBC-1997). Earthquake resisting structural systems with plan and vertical irregularities. Design and detailing of seismic resistant reinforced concrete shear-walls including boundary elements and coupling beams. Design and detailing of Moment Resisting Frames. All designs are based on the ACI-318M-14 (Ch 18) Seismic Provisions as well as the ACI-352 Beam-to-Column Connections Recommendations.

CIVE 444 SEISMIC DESIGN OF FOUNDATIONS (3.0: 3 cr. E)
This course concentrates on the modifications that foundations must be subjected to when they support structures designed for earthquakes forces. The detailing of the column-to-footing connections, shearwall-to-footing connections, and pile-to-pilecap connections according to ACI318M-14 Ch.18, are addressed. The effect of grade beams, tie beams and strap beams. Verification of punching shear under axial load and moment. The design of footings subjected to partial uplift. The seismic design of combined footings, strip footings, mat foundations and pilecaps using SAFE. Introduction to Base Isolation.
Pre-requisite: CIVE 443.

CIVE 451 CONCRETE DURABILITY (3.0: 3 cr. E)
Bases of durable concrete formulation. Early-age cracking control. The normative context regarding durability. Major durability problems: alkali–aggregate reaction in concrete, sulfate attack, steel corrosion, freeze–thaw. Durability issue in a marine environment. Consideration of durability in concrete structure design. Fire exposure.

CIVE 452 CEMENT MANUFACTURING AND HYDRATION (3.0: 3 cr. E)
The main steps of cement manufacturing. The wet, dry, semi-dry and semi-wet process. Clinker burning and Cement grinding. Quality control and Bogue calculation. Portland cement hydration. Equilibrium curves. Nucleation and growth. Heat release during hydration. Portland cement hydrates. Set regulator. Green cement.

CIVE 453 CONCRETE MATERIALS FOR SUSTAINABLE DEVELOPMENT (3.0: 3 cr. E)

Design for sustainability. Role of supplementary cementing materials in reducing greenhouse gas emissions. Recycling of demolished concrete and masonry. Glasscrete: Concrete with glass aggregate. Large-scale separation, treatment and value-added utilization of waste in concrete.

CIVE 454 CONCRETE TESTING AND REPAIR (3.0: 3 cr. E)
This course familiarizes the students with the basis of inspections of concrete structures, destructive vs. non-destructive testing methods and the rehabilitation of concrete structures. Guidelines for conducting visual inspection of concrete in service are presented in this course along with several methods for assessing the strength of concrete structures. Assessment of characteristic in-situ compressive strength by testing of cores, indirect testing (Rebound hammer test, ultrasonic pulse velocity measurement and pull-out test) and others are described.

CIVE 456 FUNDAMENTALS OF ROAD CONSTRUCTION (3.0: 3 cr. E)
This course covers an introduction to fundamental concepts in road materials and pavement construction including surface and sub-base layers. Flexible and rigid pavement construction are addressed in different stages: earthwork preparation, construction materials, drainage, surface preparation, and surface treatments. Students will be able to identify different test procedures to characterize bitumen binders and learn the method of the SUPERPAVE grading system. They will gain a working knowledge of soil/subbase behavior in addition to the geotechnical input needed for the design of road pavements.

CIVE 501 THEORY OF STEEL STRUCTURES (3.0: 3 cr. E)
The primary objective of the course is to provide the student with solid background in the fundamentals of structural steel design. Steel will be used for typical civil engineering structures such as trusses, bridges, and framed structures. Structural design establishes the configuration, details and dimensions for standard AISC rolled shapes. The course addresses the design of simple structural elements (truss members, beams, and columns in braced frames) and the design of simple connections of structural elements (welded and bolted).

CIVE 502 THEORY OF ELASTICITY (3.0: 3 cr. E)
Introduction to basic elastic theory and its application to material structures. Definition of stress, strain, tensors, generalized Hooke's law, and field equations of elasticity. Equilibrium and compatibility conditions, and the formulation of boundary value problems. Application of the stress function method and the Green's function approach for 2D and 3D problems. Prediction of defects, internal forces and failure of simple solids and structural components. Solution of elasticity problems analytically.
Pre-requisite: CIVE 424.

CIVE 503 HIGHWAY DESIGN (3.0: 3 cr. E)
The course provides a good understanding of terms and concepts that are used in highway engineering design such as location and geometric design, highway drainage, geotechnical, bituminous materials, design of flexible pavements, design of rigid pavements, operation and maintenance, noise pollution evaluation and control, and introduction to bridges. The course provides a thorough understanding of the role of highway engineering in society and the engineer's role in planning, design and operation of transportation systems, consideration of system constraints, cost, and basic design criteria.

CIVE 504 FINITE ELEMENT ANALYSIS (2.2: 3 cr. E)
This course presents finite element theory and methods for general linear and nonlinear analyses. Reliable and effective finite element procedures are discussed with their applications to the solution of general problems in structural applications. The governing continuum mechanic equations, conservation laws, and virtual work are used to establish effective finite element discretization. Furthermore, the stability, accuracy, and convergence of finite element modes are discussed. The general-purpose finite element analysis program ABAQUS is utilized to apply the theory and model structural sections.

CIVE 505 Dynamics of Structures II (3.0: 3 cr. E)
Formulation of the equations of motion for buildings with unsymmetrical plan and for continuous beams with multiple support excitations, construction of damping matrix, reduction of degrees of freedom by Rayleigh-Ritz Method, earthquake response of systems with distributed mass and elasticity, response history analysis (RHA) and response spectrum analysis (RSA) for multistory buildings, earthquake analysis and response of linearly elastic and inelastic buildings, earthquake dynamics of base isolated buildings.

CIVE 506 STABILITY OF STRUCTURES (3.0: 3 cr. E)
Buckling of discrete and continuous elastic structural systems using equilibrium analysis and energy methods. Flexural buckling of beam-columns and frames. Lateral buckling of beams. Role of shear deformation in the buckling of built-up beams and beam-columns. Basic post buckling analysis and the study of imperfection sensitivity. Stability criteria. Elasto-plastic buckling of perfect and imperfect columns. Evaluation of design code provisions.
Pre-requisite: CIVE 401.

CIVE 507 BOUNDARY SURVEYS (3.0: 3 cr. E)
Land surveying, registration laws, history, survey systems, legal principles, boundary calculations, boundary descriptions, and evidence interpretation.

CIVE 508 OCEAN ENGINEERING (3.0: 3 cr. E)
Incompressible fluid mechanics and applications to analysis of wave motions, circulations, and other free surface flows in coastal and offshore regions; wave spectra, water-level fluctuations, tides, tsunamis, oscillations, and storm surges; wind-generated waves, beaches, wave forces on coastal and offshore structures.

CIVE 509 MECHANICS OF WATER WAVES (3.0: 3 cr. E)
Irrotational theory for deep- and shallow-water waves, reflection, refraction, diffraction, attenuation. Water waves of finite amplitude. Shallow-water theory, tides, long-waves theory, conoïdal and solitary waves. Wave generation by wind. Wave breaking and reflection.
Pre-requisite: CIVE 508.

CIVE 510 MODELING OF COASTAL ENGINEERING PROBLEMS (3.0: 3 cr. E)
Mathematical modeling, differential equations of wave motion, dimensionless presentations and scaling, initial and boundary conditions, analytical solutions, numerical solutions, computer applications on selected problems.
Pre-requisite: CIVE 509.

CIVE 511 COASTAL & PLATFORMS DESIGN (3.0: 3 cr. E)
Applications of principles of ocean and coastal engineering to coastal protection structures, breakwaters, seawalls. Wave forces on offshore platforms: fixed and floating.
Pre-requisite: CIVE 510.

CIVE 512 PAVEMENT DESIGN (3.0: 3 cr. E)
The course on “Pavement Design” is designed to cover various theoretical and practical aspects of design of pavements. Different types of pavements commonly adopted for construction of low and high volume roads are introduced. The need for considering the structural and functional performance of pavements is explained. Various inputs required for design of new pavements such as climatic and traffic considerations, material characterization, analytical tools, etc. are discussed in detail. Different methods of analysis and design of bituminous and concrete pavements are discussed. Evaluation of in-service pavements and design of overlays for in-service pavements are covered in this course.

CIVE 513 TRAFFIC ENGINEERING (3.0: 3 cr. E)
This course aims at providing the student with a clear and thorough presentation of the theory and applications of Traffic Engineering. It aims at providing an understanding of the basic principles, and the ability to apply those principles. These include the traffic operations (characteristics of the driver, the pedestrian, the vehicle, and the road), traffic data collection (traffic terms and accidents) with application (traffic lights and interchanges, and level of service), and the transportation planning (the process, forecasting travel demand, evaluating transportation alternatives, and the transportation system management).

CIVE 520 PRINCIPLES OF ENVIRONMENTAL ENGINEERING (3.0: 3 cr. E)
Man and environment. Sources of environmental pollution. Water pollution and its control. Principles of water and wastewater treatment. Air pollution and its control. Solid wastes and noise problems. Environmental Impact Assessment studies. Case studies.

CIVE 521 WASTEWATER ENGINEERING DESIGN (3.0: 3 cr. E)
Sources and characteristics of wastewater. Collection works design. Theory and application of commonly used processes. Design of sludge treatment and disposal facilities. Process combinations to produce treatment systems. Case studies.
Pre-requisite: CIVE 520.

CIVE 522 WATER RESOURCES AND WATER QUALITY (3.0: 3 cr. E)
Water resources in Lebanon and around the world; Water resources regulation; Water resources usage issues; Water quality analysis and pollution control; Impacts of development on water resources and changes in water supply and availability; Water resources management.
Pre-requisite: CIVE 520.

CIVE 523 AIR POLLUTION CONTROL (3.0: 3 cr. E)
Air Pollution Effects, Measurement and Control. The influence of man-caused pollution on the atmosphere, globally and locally. Evaluation of human health, economic, and aesthetic effects of air pollution. Techniques for measurement of atmosphere pollutant concentrations and determination of local and regional air quality. Detailed presentation of air pollution sources and methods for their control. The role of local, state and federal government in air pollution control.
Pre-requisite: CIVE 520.

CIVE 524 SOLID WASTE DISPOSAL (3.0: 3 cr. E)
Generation of solid wastes. Onsite handling, storage and processing. Collection, transfer and transport of solid Wastes. Processing techniques and equipment. Recovery of resources, conversion products and energy. Disposal methods for solid wastes and residual matter: sanitary landfill, incineration, composting, and other techniques.
Pre-requisite: CIVE 520.

CIVE 525 SANITARY LANDFILL (3.0: 3 cr. E)
Disposal of solid wastes on land. Effect of leachate on groundwater pollution. Theory and current practice regarding design, construction, and monitoring of sanitary landfill. Landfill operation and economic analysis. Pre-requisites: CIVE 520 & 524.

CIVE 526 WATER SUPPLY ENGINEERING DESIGN (3.0: 3 cr. E)
Concepts in engineering, concepts in engineering design, concepts in branch design, phases of engineering designs, case studies. water characteristics, quality criteria and standards need for treatment, water treatment plant hydraulics and sludge disposal, storage and distribution system

design, intake and transmission system design, computer applications for design, economic considerations in water supply engineering design.
Pre-requisites: CIVE 520 & 522.

CIVE 527 ENVIRONMENTAL IMPACT ASSESSMENT (3.0: 3 cr. E)
Concepts of environmental impact assessment. Planning and management of impact studies. Methods of impact identifications-matrices, network and checklists. Description of environmental setting. Environmental indices and indicators for describing the affected environment. Prediction and assessment of impacts on the air, soil, water, noise, visual, socioeconomic, biological and cultural environment. Decision methods for evaluation of alternatives. Public participation in environmental decision making. Case studies.
Pre-requisites: CIVE 520 & 524.

CIVE 528 Environmental Economics and Management (3.0: 3 cr. E)
Introduction to environmental economic problems; Modeling the Market Process and Failure. Conventional and Economic Solutions to environmental problems. Environmental decision making. Environmental risk analysis. benefits and costs assessment and analysis for environmental decision making. Case studies of major environmental problems and policy solutions.
Pre-requisite: CIVE 520.

CIVE 529 Environmental Chemistry (3.0: 3 cr. E)
Theory and practice of water chemistry. Principles of chemical kinetics and thermodynamics applied to fundamental understanding of aqueous environmental samples including natural waters, wastewaters, and treated waters; factors controlling chemical concentrations, acid-base equilibria, solubility equilibria, complex formation, electrochemistry, adsorption phenomena and corrosion.

CIVE 530 Environmental Chemistry and Microbiology (3.0: 3 cr. E)
Chemistry of organic and inorganic contaminants in the environment. Natural chemical cycles in the biosphere, geosphere, hydrosphere and atmosphere, and consequences of anthropogenic disturbances. Chemical equilibrium and kinetics. Fundamentals of aquatic, atmospheric and soil chemistry. The fate of hazardous, refractory and heavy metal pollutants in the environment. Introduction to microbial taxonomy, ecology and growth kinetics of microorganisms. The microbes of public health importance in water, soil and air, including their detection, occurrence, transport, and survival in the environment. Introduction to the application of different processes to remove contaminants in natural and engineered systems.

CIVE 531 Environmental Sampling and Analysis (3.0: 3 cr. E)
Principles and methods for sampling and analysis of environmental tests such as surface water, groundwater, soil, air, and solid wastes. Physical, chemical, and biological laboratory methods for samples analyses. Sampling design for basic statistical concepts including data variability and detection of significant differences among sample sets. Data presentation and interpretation of data management methods. Off-campus lectures and demonstrations at laboratories.

CIVE 532 WASTEWATER TREATMENT PLANTS: PROCESSES, DESIGN, AND OPERATION (3.0: 3 cr. E)
Well-designed and operated wastewater treatment plants are of tremendous benefit to municipalities, industries, public health, and the environment. This course combines engineering principles, practical know-how, and useful case studies to help you improve your knowledge of the wastewater treatment process. This course explains the various methods of the wastewater treatment process and the conditions where each method is implemented best.

CIVE 555 SPECIAL TOPICS IN ENGINEERING (3.0: 3 cr. E)

Analysis and design of advanced concrete structures: stairways, reinforced concrete water tanks (rectangular and circular), concrete domes, corbels and deep beams, wind load provisions, walls, fiber polymer reinforcement, chimneys and minaret.

CIVE 556 BRIDGE DESIGN (3.0: 3 cr. E)
This course will focus on the fundamental behavior and design of reinforced and prestressed concrete bridge elements in the short and medium span range. Basic concepts of prestressing from the prestressed concrete course, commonly used methods and general design philosophy will be discussed. Service-load and ultimate-strength design of concrete bridge girders for flexure, shear and torsion effects will be studied, including serviceability constraints for control of deflection and cracking. Students will gain skills and competence in bridge design through practical design examples, presentations and a project assignment.
Pre-requisite: CIVE 405.

CIVE 557 ADVANCED STRUCTURAL STEEL DESIGN (3.0: 3 cr. E)
Introduction to plastic mechanism analysis; LRFD design of more complex structural components found in typical steel buildings; composite beams and columns, beam-to-column connections, column base plates, cover-plated beams, and built-up girders; computer applications to three-dimensional modeling techniques for steel structures; projects on structural analysis and design of trusses and frames to resist lateral wind and seismic loads.
Pre-requisite: CIVE 501.

CIVE 558 SEEPAGE, EMBANKMENTS, AND SLOPE STABILITY (3.0: 3 cr. E)
This course is designed to provide the knowledge in groundwater seepage and contaminant transport in saturated and unsaturated soils. Flow nets for homogeneous and layered soils. Design and stability analysis of embankments and earth dams.

CIVE 559 PAVEMENT RECONSTRUCTION, REHABILITATION AND MAINTENANCE (3.0: 3 cr. E)
This course is designed to provide techniques for reconstruction, rehabilitation and maintenance of flexible and rigid pavements including recycling, preventive maintenance, routine maintenance and soil stabilization design, and construction considerations.

CIVE 560 TRANSPORTATION MANAGEMENT SYSTEMS (3.0: 3 cr. E)
This course is designed to provide the knowledge to conduct the project and network-level pavement management processes, to identify the data to be collected, and to define the conditions of the transportation system.

CIVE 561 RETAINING STRUCTURES DESIGN (3.0: 3 cr. E)
Rigid and flexible earth retaining structures: rigid, anchored bulkhead, braced cut, tie-back cut, slurry trench and MSE (metallic and geosynthetic) walls with applications to infrastructure projects.

CIVE 562 DESIGN OF TIMBER STRUCTURES (3.0: 3 cr. E)
This course is designed to provide the fundamentals of design of timber structures and application to simple structures.

CIVE 563 ADVANCED SOIL MECHANICS (3.0: 3 cr. E)
This course is designed to provide a theoretical framework for the analysis of deformation and failure of soils with application to several practical problems. These include elasticity for linear deformation, plasticity models (including critical state model) for non-linear deformation and limit equilibrium analyses for important geotechnical problems.

CIVE 564 GEOSYNTHETICS (3.0: 3 cr. E)
Use of geosynthetics in civil and environmental engineering design for separation, reinforcement, and filtration, in slopes, embankments, roads, and foundations and for erosion control.

CIVE 565 SOIL-STRUCTURE INTERACTION (3.0: 3 cr. E)
Interaction between ground and structure, exchange of mutual stress between structure and foundation ground, interface of the major structural elements within a structure and the foundation material, methods of analysis and modeling, beam on elastic foundations, effect of ground movement. Site response analysis, numerical modeling of complex engineering structures interacting with soil by taking into account an effect of nonlinear soil behavior, simple elasto-plastic models for soils, groundwater flow, consolidation and other rheological phenomena. Numerical Seismic analysis and modeling for underground structures, soil-structure interaction under extreme loading conditions including performance during earthquakes, floods, landslides, large deformations due to tunneling, deep excavations, and subsidence due to dewatering and cavernous rocks.

CIVE 566 THEORY OF PLATES & SHELLS (3.0:3 cr. E)
This course introduces students to basic theory of plates including stresses and deformations, bending of plates, energy solutions, small and large displacement theories, buckling and post-buckling of plates, and behavior of plates under shear. It also familiarizes students with the characteristics of shells, the general theory of elastic shells, and membrane and bending theories for common shapes of axisymmetric structural shells. Additionally, analysis of plates and shells is performed using the finite element software ABAQUS.

CIVE 567 PHYSICAL METALLURGY OF STEELS (3.0: 3 cr. E)
This course presents the students with the metallurgy of different metals/alloys including the heat treatments, phase transformations, and properties. This course familiarizes the students with common alloys such as: carbon steels, stainless steels, high-strength low alloys steels, heat treated steels, and advanced high strength steels. This course explains the effect of alloys addition on steel properties including martensitic quench and hardenability issues. This course describes the thermo-mechanical processing of alloys, the surface treatment and coating of steel products.

CIVE 568 MANAGEMENT OF CIVIL ENGINEERING SYSTEMS (3.0: 3 cr. E)
This course introduces students to the different methodologies used in managing civil engineering systems. This course focuses on: i) Optimization methods, mainly Lagrange multipliers method, linear programming with graphical and simplex method, integer programming and network programming (shortest path, minimum spanning tree, maximum flow, minimum cost flow and transportation problems); ii) Queueing theory; iii) Decision trees; iv) Markov decision process; v) Reliability; and vi) Monte Carlo simulation.

GENG 480 FIELD TRAINING (1.0: 3 cr. E)

GENG 400, 402, 450, 590, 599
Refer to the Faculty of Engineering Requirements.