FACULTY OF ENGINEERING

DEPARTMENT OF CIVIL ENGINEERING

Master of Science (MS) Degree – 46 Credits

The Master of Science (MS) in Civil Engineering degree is 46 credits after the BS of which 37 are the transition credits from the BS program to the BE program and an additional minimum of 9 credits.

Sem	Course Code	Course Title	Credit	Pre-Req	Co-Req
7	CIVE 401	Theory of Structures II	3	CIVE 205	
7	CIVE 403	Deep Foundations	3	CIVE 307	
7	GENG 450	Advanced Engineering Analysis and Research Methodology	3		
7		Elective	3		
7		Elective	3		
Sem	**Course Code**	**Course Title**	**Credit**	**Pre-Req**	**Co-Req**
8	CIVE 402	Dynamics of Structures I	3	CIVE 401	
8	GENG 400	Engineering Seminars	1		
8	GENG 402	Project Management	3		
8	GENG 599	Master's Thesis	6	GENG 450	
8		Elective	3		
Sem	**Course Code**	**Course Title**	**Credit**	**Pre-Req**	**Co-Req**
9	CIVE 480	Field Training	3		
Sem	**Course Code**	**Course Title**	**Credit**	**Pre-Req**	**Co-Req**
10	CIVE 405	Prestressed Concrete	1	CIVE 304	
10	CIVE 503	Highway Design	3	CIVE 308	
10	GENG 599	Master's Thesis (Re-activation)	0		
10		Elective	3		
10		Elective	3		
Sem	**Course Code**	**Course Title**	**Credit**	**Pre-Req**	
11	GENG 599	Master's Thesis (Reactivation)	0		
		TOTAL	**46**		

Elective (15 credits from the following lists):					
Structural Track:					
	CIVE 411	Introduction to Earthquake Engineering and Seismology	3		
	CIVE 424	Advanced Mechanics of Materials for Civil Engineering	3	CIVE 202	
	CIVE 443	Seismic Design of Reinforced Concrete Buildings	3		
	CIVE 502	Theory of Elasticity	3		
	CIVE 504	Finite Element Analysis	3		
	CIVE 505	Dynamics of Structures II	3	CIVE 402	
	CIVE 555	Special Topics in Engineering	3		
	CIVE 556	Bridge Design	3		
	CIVE 557	Advanced Structural Steel Design	3	CIVE 324	
	CIVE 561	Retaining Structures Design	3		
	CIVE 562	Design of Timber Structures	3		
	CIVE 566	Theory of Plates and Shells	3		
Transportation Track:					
	CIVE 404	Hydraulics	3		
	CIVE 456	Fundamentals of Road Construction	3		
	CIVE 507	Boundary Surveys	3		
	CIVE 512	Pavement Design	3		CIVE 503
	CIVE 513	Traffic Engineering	3		
	CIVE 516	Advanced Geographic Information Systems	3	CIVE 323	
	CIVE 540	Sustainable Roadway Design, Construction, and Operation	3		
	CIVE 541	Contemporary Cities	3		
	CIVE 542	Sustainable Development in Transportation Engineering	3		
	CIVE 543	Sustainable Development in Civil Engineering	3		
	CIVE 556	Bridge Design	3		
	CIVE 559	Pavement Reconstruction, Rehabilitation and Maintenance	3		
	CIVE 560	Transportation Management Systems	3		
Environmental Track:					
	CIVE 438	Green Buildings and Sustainability	3		

	CIVE 520	Principles of Environmental Engineering	3		
	CIVE 521	Wastewater Engineering Design	3	CIVE 520	
	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 520	
	CIVE 526	Water Supply Engineering Design	3	CIVE 520	
	CIVE 527	Environmental Impact Assessment	3	CIVE 520	
	CIVE 528	Environmental Economics and Management	3	CIVE 520	
	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 Department	3		
Geotechnical Engineering Track:					
	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 443	
	CIVE 558	Slope Stability and Embankment Design	3		
	CIVE 561	Retaining Structures Design	3		
	CIVE 563	Advanced Soil Mechanics	3	CIVE 301	
	CIVE 564	Geosynthetics	3		
	CIVE 565	Soil-Structure Interaction	3		
Management Track:					
	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:					
	CIVE 404	Hydraulics	3		
	CIVE 409	Hydrology	3		
	CIVE 410	Applied Hydraulics	3	CIVE 404	
	CIVE 558	Slope Stability and Embankment Design	3		
Earthquake Engineering Track:					
	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 443	
	CIVE 505	Dynamics of Structures II	3	CIVE 402	
	CIVE 557	Advanced Structural Steel Design	3	CIVE 324	
Materials Track:					
	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		

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.

Pre-requisite: CIVE 205

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, sheet pile, group of piles, laterally loaded piles, efficiency of group pile, settlement of pile, braced cut, reinforced earth structure.

Pre-requisite: CIVE 307

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 prestressed 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.

Pre-requisite: CIVE 304

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

CIVE 411 INTRODUCTION TO EARTHQUAKE ENGINEERING AND 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 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 AND 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 dynamics 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.

Pre-requisite: CIVE 202

CIVE 426 BUILDING CONSTRUCTION METHODS 3.0: 3 cr. E
New Construction methods in tunneling, excavations and buildings. Immersed, cut and cover, top down methods of tunneling construction. Tunnel boring, trenchless technology, vibroflotation, jet grouting and deep water drilling are explained. Different building methods are reviewed: underpinning of foundations, earthquake resisting systems and components, new and existing formwork technologies, tilt-up wall and lift slab construction, pneumatic wedge method of concrete dome construction, volumetric construction, 3-D printing of concrete and steel, tremie concrete and underwater construction, concrete canvas, foamcrete, thin joint mortar types, polyurea, smart bricks, rammed earth, drones and 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, (iii) 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; hazards evaluation; hazard control; fault tree analysis; crane, equipment, universal, access, construction, operation and maintenance hazards; and safety measures application.

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 EURO CODE 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 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 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 480 FIELD TRAINING 0.0: 3 cr. E
Prior to MS graduation, students are expected to undergo a two- to four-month training program at an institution whereby they get exposed and engaged in activities related to their field of studies, thereby gaining experience and demonstrating their skills.

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.

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.

Pre-requisite: CIVE 308

CIVE 504 FINITE ELEMENT ANALYSIS 2.1: 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.

Pre-requisite: CIVE 402

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 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**.**

Co-requisite: CIVE 503

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 516 ADVANCED GEOGRAPHIC INFORMATION SYSTEMS **3.0: 3 cr. E**
Geographic Information Systems (GIS) are important for Civil and Infrastructure Engineering works. This advanced GIS course discusses the ArcGIS Pro and ArcGIS Online and their applications in the planning and engineering fields, network creation and management, spatial planning applications, and implementation issues. The objective is to introduce core concepts of GIS and geospatial analysis, including coordinate systems, spatial data formats, and openly available geospatial data resources. Also, this course provides hands-on experience with an industry-standard GIS to perform practical tasks that include spatial analysis and extending core GIS functionality by using ArcGIS Online. The class includes a field data collection component to expose students to GIS data creation and Global Positioning Systems (GPS).

Pre-requisite: CIVE 323

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 .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.

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.

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.

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-requisite: CIVE 520

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-requisite: CIVE 520

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-requisite: CIVE 520

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 3.0:3cr. 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 540 SUSTAINABLE ROADWAY DESIGN, CONSTRUCTION, AND OPERATION 3.0: 3 cr. E
Sustainable development is a concept that seeks to ensure that economic, environmental, and social, and cultural factors are central to the way development is taken forward to ensure the needs of society are addressed in both the present day, and in the longer term. In order for the concept of sustainable development to become embedded in national policy and legislation, the importance of sustainable development in relation to the design, operation, and construction of infrastructure has to be recognized and successfully applied. Integrating sustainable development into design enhances the performance of

assets and infrastructure. The sustainable development of road projects can deliver sustainable benefits for the environment, the economy, and the society in general.

CIVE 541 CONTEMPORARY CITIES 3.0: 3 cr. E

The "Contemporary Cities" course aims to prepare the students for the new themes of city development that are measured by new technologies and the "Urban Future". These themes are particularly related to the principles of "Sustainable Mobility" and the concept of "Smart Growth".

CIVE 542 SUSTAINABLE DEVELOPMENT IN TRANSPORTATION ENGINEERING 3.0: 3 cr. E

The course of "Sustainable Development in Transportation Engineering" aims to introduce the students to two interconnected general themes, "Sustainable Development" and "Transport Engineering", the latter being the branch of engineering that deals with the various modes of transport in their various aspects.

CIVE 543 SUSTAINABLE DEVELOPMENT IN CIVIL ENGINEERING 3.0: 3 cr. E

This course aims at providing a broad overview of the current challenges of the civil engineering sector to accomplish the expected transition to sustainable development strategies. The course starts with an overview of the usual boundary conditions of every civil engineering project and shows a procedure to carry out multidisciplinary engineering projects: the engineering design process. Next, the materials – energy – carbon relationship is covered, providing a range overview of current global issues concerning the building industry and the use of materials. The units pursue to reflect a Life-Cycle thinking. As a result of this course, students ought to become more aware of global issues and to what extent civil engineering plays an important role on tackling them. The student shall develop a more holistic vision of infrastructures, considering the entire construction cycle and being aware of positive and negative economic, social, or environmental impacts of the different infrastructures. Terms such as the sustainable development goals (SDGs), resource management, embodied energy, resilience, life-cycle will after this course sound more familiar to students.

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.

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 324

CIVE 558 SLOPE STABILITY AND EMBAKMENT DESIGN 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.

Pre-requisite: CIVE 301

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 AND 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 STEEL 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.

FACULTY OF ENGINEERING GENERAL COURSES

ENVE 401 WATER RESOURCES ENGINEERING **3.0: 3 cr. E**
This course covers the principles of ground-water development. Techniques for analyzing rainfall, runoff, fluid flow, reservoir siting, aquifer and groundwater flows. Design of reservoirs, conduits, water distribution systems, well fields, transmission lines, sewers, and drains. Well pumps. Stresses in pipes; materials and design of pipes; Metallic corrosion. Storage and distributing reservoirs, construction and maintenance. Water supply system appurtenances and special structures. Population growth and its effects on water supply requirements.

GENG 400 ENGINEERING SEMINARS **2.0: 1 cr. E**

This module consists of lectures and seminars covering recent research and advances in various fields and applications of engineering disciplines.

GENG 402 PROJECT MANAGEMENT **3.0: 3 cr. E**
To make available the fundamentals of project management with the most workable types of organizations and the necessary capabilities that must be included to reasonably ensure success and minimize the possibility of failure. The course consists of construction contracting for contractors, owners, and engineers: bidding, industry structure, types of contracts, and delivery systems of construction, planning, estimating, quantity take-off and pricing, labor and equipment estimate, proposal preparation, contract documents to prepare detailed estimates, permits, risk management, and taxes. Basic critical path planning and scheduling with activity on nodes and activity on arrows, monitoring, updating, controlling, crashing, resource leveling, resource allocation, and least cost scheduling including time-cost trade-off analysis. Computer applications using the Primavera software.

GENG 450 ADVANCED ENGINEERING ANALYSIS AND RESEARCH METHODS 3.0: 3cr. E
The aim of this course is to train MS students in the methodologies used for research. Starting from existing literature, students will learn the formulation and development of original research problems in engineering management and civil engineering. The focus of the course is how to plan, prepare and present research manuscripts, such theses, and papers. Overview of the most popular modeling techniques, and statistical sampling methods used for engineering research.

GENG 599 MASTER'S THESIS **6.X: 6 cr. E**
An approved final thesis project.

Refer to General Listing of Course Descriptions for:

BIOL XXX
Refer to Faculty of Arts and Sciences

CHEM XXX
Refer to Faculty of Arts and Sciences

CSIS XXX
Refer to the Faculty of Arts and Sciences

CSPR XXX
Refer to the Faculty of Arts and Sciences

ENGL XXX
Refer to the Faculty of Arts and Sciences

ENMG XXX
Refer to the Department of Engineering Management

EVSC XXX
Refer to the Faculty of Arts and Sciences

GENG XXX
Refer to the Faculty of Engineering Requirements

LISP XXX
Refer to the Faculty of Arts and Sciences

MATH XXX
Refer to the Faculty of Arts and Sciences

MECH XXX
Refer to the Department of Mechanical Engineering

MGMT 220, MRKT 456
Refer to the Faculty of Business and Management

PHYS XXX
Refer to the Faculty of Arts and Sciences