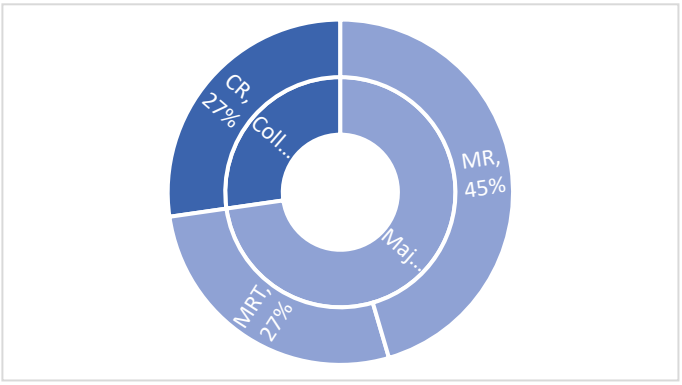
M.Sc. in Civil Engineering 2018

The Civil Engineering 2018 M.Sc. Program for Batch 2018 Onwards

Program Components

Specializations: Structural Engineering – Traffic and Transportation Engineering – Water Resources and Environmental Engineering – Geomatics Engineering

Course Type	CRD
University Requirement (UR)	--
College Requirement (CR)	09
Major Requirement (MR)	15
Major Elective (ME)	--
Major Support Requirement (MSR)	--
Minor Requirements (Minor)	---
Master Thesis	09
Total Credits (CRD)	33



Detailed Study Plan

COMMON COURSES FOR ALL TRACKS (Sem.1)

Year 1 Semester 1

Course	Course Title	Course Hours			Course Type	Prerequisite	Major GPA
		LEC	PRAC	CRD			
CENG580	Advanced Construction Project Management	3	0	3	CR	--	Yes
CENG582	Numerical Methods for Differential Equations	3	0	3	CR	--	Yes
CNEG513	Finite Element Methods	3	0	3	CR	--	Yes
	Total	9	0	9			

Year 1 Semester 2

Course	Course Title	Course Hours			Course Type	Prerequisite	Major GPA
		LEC	PRAC	CRD			
CENGXXX	Elective Course from Field of Specialization	3	0	3	MR	Completion of three core courses	Yes
CENGXXX	Elective Course from Field of Specialization	3	0	3	MR	Completion of three core courses	Yes
CENGXXX	Elective Course from Field of Specialization	3	0	3	MR	Completion of three core courses	Yes
	Total	9	0	9			

Year 2 Semester 3

Course	Course Title	Course Hours			Course Type	Prerequisite	Major GPA
		LEC	PRAC	CRD			
CENGXXX	Elective Course from Field of Specialization	3	0	3	MR	Completion of three core courses	Yes
CENGXXX	Elective Course from Field of Specialization	3	0	3	MR	Completion of three core courses	Yes
	Total	6	0	6			

Year 2 Semester 4

Course	Course Title	Course Hours			Course Type	Prerequisite	Major GPA
		LEC	PRAC	CRD			
CENG599	Masters Thesis	9	0	9	MR	Completion of three core courses and 5 elective courses from one specialization	Yes
	Total	9	0	9			

Year 3 Semester 5

Course	Course Title	Course Hours			Course Type	Prerequisite	Major GPA
		LEC	PRAC	CRD			
CENG599	Masters Thesis	9	0	9	MR	Completion of three core courses and 5 elective courses from one specialization	Yes
	Total	9	0	9			

Total credit hours required in the program = 33

List of Elective Courses

(STRUCTUAL ENGINEERING TRACK)

Course	Course Title	Course Hours			Course Type	Prerequisite	Major GPA
		LEC	PRAC	CRD			
CENG501	Advanced Mechanics of Materials	3	0	3	ME	Completion of three core courses	Yes
CENG511	Plates and Shells	3	0	3	ME	Completion of three core courses	Yes
CENG512	Matrix Structural Analysis	3	0	3	ME	Completion of three core courses	Yes
CENG514	Structural Stability	3	0	3	ME	Completion of three core courses	Yes
CENG516	Structural Dynamics	3	0	3	ME	Completion of three core courses	Yes
CENG517	Advanced Steel Design	3	0	3	ME	Completion of three core courses	Yes
CENG518	Pre-Stressed Concrete	3	0	3	ME	Completion of three core courses	Yes
CENG538	Shallow and Deep Foundations	3	0	3	ME	Completion of three core courses	Yes
CENG539	Bridge Engineering	3	0	3	ME	Completion of three core courses	Yes
CENG590	Advanced Reinforced Concrete Design	3	0	3	ME	Completion of three core courses	Yes

List of Elective Courses

(TRANSPORTATION AND TRAFFIC ENGINEERING TRACK)

Course	Course Title	Course Hours			Course Type	Prerequisite	Major GPA
		LEC	PRAC	CRD			
CENG540	Pavement Design	3	0	3	ME	Completion of three core courses	Yes
CENG541	Advanced Traffic Engineering	3	0	3	ME	Completion of three core courses	Yes
CENG542	Transportation Planning and Modeling	3	0	3	ME	Completion of three core courses	Yes
CENG544	Environmental Appraisal of Transportation Activities and Economics	3	0	3	ME	Completion of three core courses	Yes
CENG545	Road Safety Audit	3	0	3	ME	Completion of three core courses	Yes
CENG546	Advanced Pavement Material	3	0	3	ME	Completion of three core courses	Yes
CENG547	Pavement Maintenance Program	3	0	3	ME	Completion of three core courses	Yes
CENG548	Public Mass Transportation Systems	3	0	3	ME	Completion of three core courses	Yes
CENG549	Transportation and Land Use Planning	3	0	3	ME	Completion of three core courses	Yes

List of Elective Courses

(WATER RESOURCES AND ENVIRONMENTAL ENGINEERING TRACK)

Course	Course Title	Course Hours			Course Type	Prerequisite	Major GPA
		LEC	PRAC	CRD			
CENG520	Groundwater Resources Engineering	3	0	3	ME	Completion of three core courses	Yes
CENG521	Advance Wastewater Treatment	3	0	3	ME	Completion of three core courses	Yes
CENG522	Hydraulics of Closed Conduits	3	0	3	ME	Completion of three core courses	Yes
CENG580	Advanced Hydrology	3	0	3	ME	Completion of three core courses	Yes
CENG582	Chemistry in Environmental Engineering	3	0	3	ME	Completion of three core courses	Yes
CENG583	Hazardous and Industrial Waste Management	3	0	3	ME	Completion of three core courses	Yes
CENG584	Water Resources and Environmental Systems	3	0	3	ME	Completion of three core courses	Yes
CENG585	Free Surface Flow	3	0	3	ME	Completion of three core courses	Yes
CENG586	Coastal Engineering	3	0	3	ME	Completion of three core courses	Yes
CENG587	Groundwater Contamination and Pollutant Transport	3	0	3	ME	Completion of three core courses	Yes

List of Elective Courses

(GEOMATICS ENGINEERING TRACK)

Course	Course Title	Course Hours			Course Type	Prerequisite	Major GPA
		LEC	PRAC	CRD			
CENG523	Adjustment Computation of Spatial Data	3	0	3	ME	Completion of three core courses	Yes
CENG524	Geospatial Data Management	3	0	3	ME	Completion of three core courses	Yes
CENG525	Remote Sensing and Image Interpretation	3	0	3	ME	Completion of three core courses	Yes
CENG526	Geospatial Image Processing	3	0	3	ME	Completion of three core courses	Yes
CENG527	Digital Photogrammetry	3	0	3	ME	Completion of three core courses	Yes
CENG528	Digital Cartography and Map Projection	3	0	3	ME	Completion of three core courses	Yes
CENG529	GIS and Spatial Data Acquisition	3	0	3	ME	Completion of three core courses	Yes
CENG534	Geodesy and Satellite Data Positioning	3	0	3	ME	Completion of three core courses	Yes
CENG537	Close Range Photogrammetry	3	0	3	ME	Completion of three core courses	Yes
CENG542	Practicum GPS	3	0	3	ME	Completion of three core courses	Yes

Course Description
Common Courses for All Tracks

CENG580: Advanced Construction Project Management	**(3-0-3)**
Prerequisite: None	
Focuses on effective project/program management approaches and techniques with specialized emphasis on major private sector engineering projects and major government system acquisitions. Understanding of the construction project delivery process and key management factors for achieving project success (the principals and application of the nine area of knowledge management), value engineering, conceptual estimating, construction productivity, scheduling, budgeting, project controls and simulation of construction operations, basic knowledge of competing values framework management model.	

CENG582: Numerical Methods for Differential Equations	**(3-0-3)**
Prerequisite: None	
Ordinary differential equations, Numerical solution of initial value problems, Runga-Kutta methods and multi-step methods, Numerical solution of boundary value problems, shooting method, finite difference method, Nonlinear boundary value problems, Partial differential equations, modern numerical techniques for linear and nonlinear elliptic, parabolic and hyperbolic partial differential equations, Finite Difference and Finite Volume Discretization; Finite Element Discretization; Boundary Element discretization; Direct and Iterative Solution Methods.	

CENG513: Finite Element Method	**(3-0-3)**
Prerequisite: None	
Stiffness method, finite element forms using energy methods, element formulation using assumed displacement fields, isoperimetric formulation, formulation of plane, three dimensional, and plate and shell elements. Use of commercially available programs.	

CENG599: Thesis	**(9-0-9)**
Prerequisite: Completion of three core courses and 5 elective courses from one specialization	
The Master's Thesis represents the culmination of the research project, carried out by the student as a part of his graduation requirements. The research project and research findings must have some elements of originality either in substance or in approach. The research topic can be either applied or basic in nature.	

COURSES IN STRUCTURAL ENGINEERING TRACK

CENG501: Advanced Mechanics of Materials	**(3-0-3)**
Prerequisite: Completion of three core courses	
Theory of stress and strain; elastic, plastic, elastic-plastic and viscous-elastic material behavior and failure; energy methods; unsymmetrical bending, nonlinear and elastic-plastic bending; beams on elastic foundation; shear and torsion of thin-walled cross section; curved beams.	

CENG511: Plates and Shells	**(3-0-3)**
Prerequisites: Completion of three core courses	
Elements of plate bending theory, circular plates, rectangular plates, plates of various geometrical forms, numerical methods, anisotropic plates, plates under combined lateral and in-plane loads, large deflection of plates, thermal stresses in plates, membrane and bending stresses in shells, application to pipes, tanks and pressure vessels, cylindrical shells under general loads. Crushing and bending strength of cylindrical shells.	

CENG512: Matrix Structural Analysis	**(3-0-3)**
Prerequisites: Completion of three core courses	
Definitions and concepts, formation of global analysis equations, stiffness analysis of frames; element stiffness matrix, coordinate transformation, loads between nodal points, initial and thermal strain conditions. Virtual work principles in framework analysis, nonlinear analysis of frames, geometric nonlinear and elastic critical load analysis, material nonlinear analysis, solution of nonlinear equilibrium equations, special analysis procedures.	

CENG514: Structural Stability	**(3-0-3)**
Prerequisites: Completion of three core courses	
Buckling of columns, linear elastic theory, initial imperfection, large deformation theory, Analytical and numerical methods for the treatment of elastic instability. Approximate methods; buckling problems in beams, columns, and frames; Beam-column buckling. Lateral and torsional instability; energy and numerical methods.	

CENG516: Structural Dynamics	**(3-0-3)**
Prerequisites: Completion of three core courses	
Dynamic response of structures modeled as single degree of freedom systems, lumped systems, and multi-degree of freedom systems. Numerical evaluation of system responses due to general loading; blasts, wind, and earthquake loading. Earthquake analysis by response history and response spectrum and structural dynamics in building codes.	

CENG517: Advanced Steel Design	**(3-0-3)**
Prerequisites: Completion of three core courses	
Prerequisite: completion of three core courses Plastic Design of steel frames. Limit state design. Design of single-story industrial buildings; structural framing, three-dimensional stability, gable frames. Flexural torsional stability of hotrolled steel sections. Design of multi-story steel frames. Design of beam column connections. Torsional analysis of thin-walled sections; warping, bi-moment, sectorial coordinate, warping moment of inertia.	

CENG518: Pre-Stressed Concrete	**(3-0-3)**
Prerequisites: Completion of three core courses	
Pre-stressed materials, methods, and systems. Behavior and design of members subjected to axial forces, flexure, shear, and torsion; effect of prestressed losses; partial prestressing, load balancing and composite design; anchorage0zobne design; applications to continuous beams, slabs and bridge design. Deflection.	

COURSES IN TRAFFIC AND TRANSPORTATION ENGINEERING TRACK

CENG538: Shallow and Deep Foundations	**(3-0-3)**
Prerequisite: Completion of three core courses	
Layered and anisotropic soils, foundations with uplift and tension forces. Foundation on sand deposit, design of mat foundations. Tension piles, laterally loaded piles, pile buckling, wave equation, pile driving stresses.	

CENG539: Bridge Engineering	**(3-0-3)**
Prerequisite: Completion of three core courses	
Overview and History of Bridges. Bridge definition and components, Planning of Bridges; traffic studies, hydrotechnical studies, environmental considerations, economic feasibility of a bridge. Factors considered in deciding bridge type, Aesthetics in bridge design, AASHTO Bridge design code. Loadings; gravity, lateral, collision loads, forces due to deformations Geometric design considerations. Selection of suitable bridge type, introduction to bridge design methods. Concrete deck design, Solid slab bridge design, T-beam bridge design, Prestressed concrete girder bridge, concrete box girder bridge, various types of bridge foundation, spread footings, piles, caissons, abutments, design requirements, Types of joints in bridges, types of bearings used in bridges, Bridge inspections and maintenance.	

CENG590: Advanced Reinforced Concrete Design	(3-0-3)
Prerequisite: Completion of three core courses	
Review of reinforced concrete behavior, material properties for reinforced concrete; stress-strain relationship for confined and unconfined concrete, stiffness of reinforced concrete; moment-curvature relationship in reinforced concrete, computation of the M-Φ relationship, M-Φ relationship for columns, influence of various parameters, minimum reinforcement for flexure, nonlinear behavior of reinforced concrete; ductility, hysteretic behavior, energy absorption and dissipation, inelastic moment redistribution, inelastic analysis of concrete structures, pushover analysis, shear walls, beam-column connections; monolithic joints, behavior in inelastic range, shear effects, shear and torsion of reinforced concrete members, strut and tie approach.	

COURSES IN TRAFFIC AND TRANSPORTATION ENGINEERING TRACK

CENG540: Pavement Design	(3-0-3)
Prerequisite: Completion of three core courses	
Development of highway construction in Bahrain, pavement types, principles in the conventional and structural design and consideration of highway and airport pavements. Traffic assortment and consideration. Climatic influences on pavements. Economic, design strategies. Materials characterization. Design of asphaltic mixtures. Evaluation and maintenance of pavements.	

CENG541: Advanced Traffic Engineering	(3-0-3)
Prerequisite: Completion of three core courses	
Prerequisite: completion of three core courses Review of road users, Traffic control devices, applications of control measures, advanced traffic analysis and prediction, traffic flow theory, traffic signal control, capacity, and level of service at signalized intersection, highway capacity for freeways, roundabout capacity models, urban and rural areas, special topic in highway safety.	

CENG542: Transportation Planning and Modeling	(3-0-3)
Prerequisite: Completion of three core courses	
Review of mathematical prerequisites, system analysis and principles of modeling in transportation, data, space and travel demand, urban transportation planning process, inventory, trip generation, trip distribution, model split, network assignment, transportation evaluation, and equilibrium supply-demand system.	

CENG544: Environmental Appraisal of Transport Activities And Economics	**(3-0-3)**
Prerequisite: Completion of three core courses	
Planning theory, planning framework, planning framework; infrastructure, mobility, and society; sustainable communities. Traffic management techniques; economic and environmental appraisal of transport activities; air pollution modeling; traffic and environmental management for sustainability; public enquiry into transport scheme; project management; railway management; economics and planning; design of transport infrastructure; travel demand forecasting; international freight policy and practice.	

CENG545: Road Safety Audit	**(3-0-3)**
Prerequisite: Completion of three core courses	
Safety design and operational practices for streets and highways including safety improvement programs, design of barrier systems, bicycle and pedestrian consideration; access control; safety evaluation; and measures of effectiveness.	

CENG546: Advanced Pavement Material	**(3-0-3)**
Prerequisite: Completion of three core courses	
Selecting materials for highway construction, testing aggregates and bituminous materials, designing and testing asphalt mixtures; and recommending maintenance and rehabilitation strategies for deteriorated pavements.	

CENG547: Pavement Maintenance Program	**(3-0-3)**
Prerequisite: Completion of three core courses	
Pavement evaluation and performance, evaluation of pavement distress condition surveys, evaluation of pavement roughness ride quality, skid resistance of pavements, evaluation of pavement structural capacity, maintenance and rehabilitation, prioritization and optimization of pavement maintenance, and rehabilitation needs.	

CENG548: Public Mass Transportation	**(3-0-3)**
Prerequisite: Completion of three core courses	
Service characteristics of the principal modes of public mass transportation with emphasis on urban transit (fixed-route bus, light rail, subways, commuter rail, par transit, taxi); legislation and regulations; institutional structures; financing; need and demand studies; planning strategies; management; operations and record keeping; case studies of leading systems.	

CENG549: Transportation and Land Use for Planning	**(3-0-3)**
Prerequisite: Completion of three core courses	
Examination of the interactions between transportation and land use systems; historical perspectives on transportation; characteristics of travel and demand estimation; evaluation of system performance; location theory; models of transportation and urban structure; empirical evidence of transportation-land use impacts; case study examinations.	

COURSES IN WATER RESOURCES AND ENVIRONMENTAL ENGINEERING TRACK

CENG520: Ground Water Resources Engineering	**(3-0-3)**
Prerequisite: Completion of three core courses	
Groundwater occurrence, vertical distribution, basins, and tracers. Types of aquifers and coefficients. Differential equations of groundwater flow. Steady radial flow to a well. Unsteady radial flow in confined, unconfined, and leaky aquifers. Aquifer boundaries. Well losses. Analysis and evaluations of pumping test data. Quality of groundwater. Management of groundwater-concepts, evaluation of losses. Analysis and evaluations of pumping test data. Quality of groundwater. Management of ground water-concepts, evaluation of hydrologic equilibrium, data collection and examples of management. Groundwater modeling techniques.	

CENG521: Advanced Wastewater Treatment	**(3-0-3)**
Prerequisite: Completion of three core courses	
Introduction to biological treatment of wastewater. Factors affecting the treatment of wastewater in waste stabilization pond systems. Nitrogen and phosphorus removal from wastewater. Treatment of sewage sludge. Reuse of treated wastewater and sewage sludge.	

CENG522: Hydraulics of Closed Conduits	**(3-0-3)**
Prerequisite: Completion of three core courses	
Concept of water hammer and unsteady flow through conduits; pipe transmission and distribution systems design including flow control, flow measurement, energy dissipation, pump selection, transients and cavitations. Computer modeling and case studies.	

CENG580: Advanced Hydrology	**(3-0-3)**
Prerequisite: Completion of three core courses	
Elements of hydrologic cycle; frequency analysis of precipitation and runoff; Advanced hydrologic analysis of floods, sediment, water utilization, flow routing, and the application of special hydrologic problems.	

CENG582: Chemistry in Environmental Engineering	**(3-0-3)**
Prerequisite: Completion of three core courses	
Environmental aspects of physical, organic, and inorganic chemistry including applications in environmental engineering of the phenomena of precipitation, buffering capacity, chemical equilibrium, and adsorption. Case studies on problems/solutions encountered by environmental and civil engineers.	

CENG583: Hazardous and Industrial Waste Management	**(3-0-3)**
Prerequisite: Completion of three core courses	
A general treatment of hazardous waste management problem and regulatory climate surrounding the storage, transportation, treatment, and disposal of hazardous waste. Sources and treatment of various industrial wastewaters. Relationship between risk assessment and treatment/disposal facility design. Design of landfills and incinerators. Case studies on waste minimization and resource recovery.	

CENG584: Water Resources and Environmental Systems	**(3-0-3)**
Prerequisite: Completion of three core courses	
Application of system engineering techniques to water and environmental problems; optimization techniques, linear programming, integer programming, non-linear programming, dynamic programming; multi-objective decision analysis, simulation methods.	

CENG585: Free Surface Flow	**(3-0-3)**
Prerequisite: Completion of three core courses	
Application of fundamentals of fluid mechanics to problems of free surface flow; computation of steady and transient water surface profiles; stratified flows in reservoirs and estuaries; diffusion; transition structures; sediment transport.	

CENG586: Coastal Engineering	**(3-0-3)**
Prerequisite: Completion of three core courses	
General description of wave systems including spectral representation; solutions to oscillatory wave equation; wave breaking, harbor resonance; wave shoaling; refraction, and diffraction; wave forecasting; selection of design wave conditions; forces on coastal structures; shoreline erosion processes.	

CENG587: Ground Water Contamination and Pollutant Transport	**(3-0-3)**
Prerequisite: Completion of three core courses	
Application of groundwater flow principles, transport phenomena, and chemical and biological processes to problems of groundwater contamination. Planning and executing a successful sampling event, field equipment decontamination methods, water level and product thickness measurement. Simulation model and case studies of current topic.	

COURSES IN GEOMATICS ENGINEERING TRACK

CENG523: Adjustment Computation of Spatial Data	**(3-0-3)**
Prerequisite: Completion of three core courses	
Application of statistical theory to the adjustment of redundant data using the method of least squares. Errors in engineering measurements. Use of probability distributions. Use of statistical tests. Law of propagation of errors. Mathematical models and formulation of observation and condition equations. Weight matrix. Some techniques of adjustment. Solution of normal equations. Precision of unknowns and functions of unknowns. Variance and covariance matrix. Error ellipses and confidence regions. Statistical testing, accuracy, and reliability.	

CENG524: Geospatial Database Management	**(3-0-3)**
Prerequisite: Completion of three core courses	
Spatial versus non-spatial databases, Database management system architecture, Entity Relationship Modeling and Design (Conceptual Modeling), Relational Data Model and Relational Algebra (Logical Modeling) , query and manipulate databases through Structured Query Language (Physical Modeling), Normalization, relational database design methods and algorithms Object-oriented and object-relational databases, Web-based database applications , Query processing and optimization , Geo-database design.	

CENG525: Remote Sensing and Image Interpretation	**(3-0-3)**
Prerequisite: Completion of three core courses	
Concepts and foundation, elements of photographic system, Visual image interpretation, multispectral scanning, thermal sensing, earth resources satellites operating in the optical spectrum, LandSats imaging, Spots satellite programs, ocean monitoring satellites, Space station, Radar imaging satellites, Side looking Radar system, Radar image interpretation, Lidar sensing, and applications.	

CENG526: Geospatial Image Processing	**(3-0-3)**
Prerequisite: Completion of three core courses	
Advanced techniques for analysis and interpretation of remotely sensed imagery, with emphasis on data acquired from satellite and airborne platforms. Methods of enhancement and display, including histogram transformation, detection and characterization of texture, edge and line, and filtering. Techniques for feature extraction, including clustering and related statistical methods, such as maximum likelihood estimation, decision tree structures, contextual classification, and knowledge-based methods. Procedures for handling multitemporal (time-varying) data for topographic map updating and resource monitoring. Selected case studies.	

CENG527: Digital Photogrammetry	**(3-0-3)**
Prerequisite: Completion of three core courses	
Theory of photography, Basic camera components and camera calibration. Relief Displacement, Parallax. Reduction and refinement of image coordinate measurements. Vertical Photography, Mathematical Model, Projection alternatives, Collinearity equations and Least squares adjustment in Photogrammetry. Theory of Orientation, Interior orientation, Exterior orientation, Relative orientation, Absolute orientation, Resection, Intersection, Aerial triangulation, Block Triangulation, and Block Adjustment with Self Calibration. Planning Aerial Photography, Digital terrain modeling and Ortho-photo generation.	

CENG528: Digital Cartography and Map Projection	**(3-0-3)**
Prerequisite: Completion of three core courses	
Overview of map projections. Analysis of map projections characteristics with equi-area, equi-distance, equi-azimuthal and conformal projections. Conformal mapping of the biaxial ellipsoid onto a plane: Mercator, Transverse Mercator, Lambert Conformal Conic and Stereographic. Map accuracy, design compilation, projections, editing & reproduction. Engineering use of cartographic data. Map updating and completion. Map drawing. Graphic design considerations in map making and governing factors. Graphic elements, including color, topography, generalization. Production planning and control, editing, revision and cost estimates. Introduction to computer assisted cartography: objectives, hardware, and software. Automated image formation, digitizing and plotting. Applications of map projections; UTM, JTM, etc.	

CENG529: GIS And Spatial Data Acquisition	**(3-0-3)**
Prerequisite: Completion of three core courses	
The basic concepts, Hardware and software components, Sources of spatial and non-spatial data sources, thematic characteristics of spatial data, entity definition, spatial data model, spatial data structures, creating geo-spatial data base, methods of data input, spatial and non-spatial data editing, output formats, data analysis, measurements in GIS, quires, reclassification, buffering and neighborhood function, maps overlays, spatial interpolation, 2-Dimension analytical functions, process models, mechanism of delivery, GIs and decision support, data quality and error management in spatial data.	

CENG534: Geodesy and Satellite Positioning	**(3-0-3)**
Prerequisite: Completion of three core courses	
The Earth's gravitational field. Gravity and gravitation. Gravity, gravitational, and rotational potential. Analytical and numerical integration of orbits. Satellite geodetic models: geometric, kinematic, and dynamic. Observation types. Fundamentals underlying satellite geodetic and analysis software. The World Geodetic System 1984. Differential coordinate transformation techniques, GPS, GNSS, GLONASS and Galileo constellation system characteristics.	

CENG537: Close-Range Photogrammetry	**(3-0-3)**
Prerequisite: Completion of three core courses	
Photogrammetric Process and Image forming model, Coordinate system, coordinate transformations, Adjustment techniques and geometric elements. Imaging configurations, interior orientation, resolutions, sampling theory, object targeting and illumination techniques. Bundle triangulation, Direct Linear Transformation (DLT), object reconstruction, line Photogrammetry and Epipolar geometry. Network geometry and Constraint design, Image matching and 3D object Reconstruction.	

CENG542: GPS Practicum	**(3-0-3)**
Prerequisite: Completion of three core courses	
Presentation of all types of GPS-GNSS equipment with their uses and limitations, GPS observation planning based on satellite geometry and obstructions, review of geodetic coordinate systems and datum's, the geoid and how it relates to the production of elevations from GPS, execution of all components (planning, field collection, downloading, processing, and adjustment) of a GPS survey where raw data is collected, real time kinematic (RTK) GPS field execution and adjustment for control work, use of RTK GPS in collection of a topographic survey, integrating GPS with spatial data and GIS.	