COURSE DESCRIPTIONS for the Degree of Ph.D. in Civil Engineering, Major: *Structural Engineering*

1610700 Advanced Engineering Math II 3 Cr. Application of Functional Analysis, Application of Specific Functions in Solution of Boundary Values, Application of Green Functions, Solution of Partial Differential Equations, Application of Perturbation in Solution of Partial Differential Equations

1612702 Finite Element II 3 Cr. Introduction to Nonlinear Analysis, Kinematics of the Body, The basic problem, the deformation gradient, strain and stress tensors, Total Lagrangian, updated Lagrangian formulation, Eulerian formulation, Displacement – based finite elements, Linearization of the principal of virtual work with respect to finite element variables, Truss and cable elements, Two dimensional plane stress and plane strain problems, Axisymmetric problem, Three – Dimensional solid elements, Structural elements, Beam element, Axisymmetric shell element, Plate and general shell element, Solution of nonlinear equations, Tangent and secant method, Iteration, Newton – Raphson, Arc- length method

1612710 Computational Plasticity 3 Cr. **An Overview of Plasticity Theory:** Mathematical Fundamentals, The Physics of Plasticity (Metals, Soils, Rocks, Concrete), Highlights of Continuum Mechanics, Yield Criteria, Flow Rules and Hardening Rules, Drucker's Stability Postulate, Maximum-Dissipation Postulate, Normality and Uniqueness, Incremental Stress-Strain Relations Using Stress-Space and Strain-Space, Hardening Models, **Computational Techniques:** Finite-Element Formulation for Nonlinear Problems, Numerical Algorithms for Solving Nonlinear Problems (Time Marching Algorithms), Elastic-Plastic Operator Split (Elastic Predictor and Plastic Corrector), Return Mapping Algorithms, Cutting Plane and Closest Point (and Linearization), Return Mapping Algorithm for J2 Plasticity with Mixed Isotropic/Kinematic Hardening (and Linearization), Return Mapping Algorithm for General Plasticity Models with General Linear/Non-Linear Mixed Hardening Involving Linear/Non-Linear Elastic Behavior (and Linearization), Multi-Surface Plasticity (Non-Smooth Surfaces), Return Mapping Algorithm for Problems with Non-Smooth Yield Surfaces (and Linearization), Mixed Formulations in the Finite Element Method (Problems with Incompressible Material), Formulation in Elasto-Plasticity Problems with Yield Surface Independent of the Mean Stress, The B-bar Method, Highlights of Visco-Plasticity and Implementation in the Finite Element Method

1612530 Stability of Structures 3 Cr. Introduction: What is buckling?, Importance of Buckling Load, Historical Review, Buckling and Post Buckling of Bars with Finite Degrees of Freedom, Buckling and Post Buckling of Columns, Buckling of Beams Columns, Inelastic Buckling of Plates, Slope Deflection and Moment Distribution Methods for Buckling Analysis of Frame, Finite Element Method for Frame Buckling, Exact Finite Element Method for Frame Buckling, Lateral Torsional Buckling of Beams, Local and Post Local Buckling of Plates, Finite Element Method for Plate Buckling, Finite Strip Method for Plate Buckling

1612600 Earthquake Engineering 3 Cr. Earthquake Ground Motion, Seismic Behavior of Structures, Ductility and Modeling of Load Bearing Systems, Elastic and Inelastic Earthquake Analyses of Structures, Introduction to Performance Based Design, Structural Control, Soil-Structure Interaction

COURSE DESCRIPTIONS for the Degree of Ph.D. in Civil Engineering, Major: *Water Engineering*

1610700 Advanced Engineering Math II 3 Cr. Application of Functional Analysis, Application of Specific Functions in Solution of Boundary Values, Application of Green Functions, Solution of Partial Differential Equations, Application of Perturbation in Solution of Partial Differential Equations

1614702 Advanced Hydrodynamics **3 Cr.** Vector algebra, divergence, curl, polar and cylindrical coordinates, body forces, pressure, Reynolds analogy, vortices, Stokes law, motion equations, continuity, circulation, Navier-Stokes Equations for laminar and turbulent flows, inviscid flow, incompressible irrotational flow, Laplace equations, Kelvin theory, Balsius theory, flow field, viscous flow, low Reynolds flow, boundary layer, instability of flow, turbulence, turbulent boundary layer, separation, drag and lift forces

1614706 Water Resources systems Analysis II 3 Cr. The course will focus on the quantitative approach for identifying and evaluating alternative possible decisions and their physical, economic, environmental, and social impacts of water resources systems. Modeling methods include various deterministic and probabilistic optimization and simulation models, decision analysis, evolutionary search algorithms and multiobjective planning and management models

1614712 Advanced Hydrogeology **3 Cr.** Basic assumptions: Darcy's law, Solution of flow equations, Unsteady flow in aquifers (confined and unconfined), Unsaturated flow in porous media and soil moisture profile, Regional groundwater flow: Steady and transient flow in regional groundwater systems, , Interaction of groundwater and surface water (lakes, wetland and rivers), Groundwater flow modeling: techniques, simulation of two and three-dimensional groundwater systems, Groundwater modeling in the complex hydrosystem, Numerical methods in groundwater flows (finite differences), different initial and boundary conditions, Stability of schemes, Management of groundwater: Concepts of basin management, Conjunctive use of surface water and groundwater: Optimal control groundwater management models, Case study.