MSc specialisation in Numerical Modeling
Final exam questions

Finite element method for civil engineers (BMEEOTMMS51)

1. Theorem of stationarity of potential energy. Potential of elastic structures. Solution of structures (bars in tension, bars in bending) by energy method. Solution by energy method using basis functions. Piecewise zero basis functions. Continuity of basis functions.
2. Typical finite elements in case of bar structures (truss and beam elements). Nodes, DOFs, coordinate systems (global, local, parametric), shape functions, considerations for the calculation of matrices of the finite element. Euler and Timoshenko beam theories.
3. Typical finite elements in case of plane membranes. Nodes, DOFs, coordinate systems (global, local, parametric), shape functions, considerations for the calculation of matrices of the finite element. Plane stress, plane strain.
4. Compilation of the global stiffness matrix and vector of nodal forces. Consideration of supports. Calculation of reactions and stresses. Coordinate transformation.

Stability of structures (BMEEOHSMT-2)

1. Static, energy, and kinetic method, in structural stability. Flexural buckling of compressed columns with various end conditions, including pinned and fixed supports, and supports with rotational springs.
2. The flexural behaviour of a pinned-pinned compressed column with an initial geometric imperfection. Derivation and application of the Ayrton-Perry formula. Buckling of columns with discrete lateral spring. Buckling of columns with elastic foundation.
3. Torsion of thin-walled members: Saint-Venant torsion, warping, sectoral coordinates, warping constant, bimoment, stresses associated with warping. Basics of flexural-torsional and lateral-torsional buckling.
4. Buckling of simply supported rectangular plates under uniaxial compression. The concept of ‘k’ factor. Buckling of rectangular plates with a free edge. Shear buckling. The effect of stiffeners on plate buckling. The effective width approach.

Structural dynamics (BMEEOTMMN-1)

1. Partial differential equation of the lateral vibration of a continuous beam; solution of the free vibration problem for a simple supported girder; response of the beam to a harmonic excitation force.
2. Dynamic stiffness matrix and the exact mass matrix of a frame structure undergoing a harmonic forcing; approximate mass matrices (lumped mass matrix, consistent mass matrix), accuracy of the approximation.
3. Consideration of the structural damping as a complex stiffness; complex dynamic stiffness matrix of a beam element; physical background of proportional damping, rate-independent damping.
4. Elastic stiffness of the supporting soil body modelled as an infinite elastic half-space; dynamic stiffness of the soil due to harmonic forcing; radiation damping.

Nonlinear mechanics (BMEEOTMMN-2)

1. The deformation gradient tensor. Different versions of the strain-, strain velocity- and stress tensors of the nonlinear mechanics. The meaning of the invariants of stress- and strain tensors. The importance of the second invariant of the deviatoric stress tensor.
2. The first and second laws of thermodynamics. The most important requirements of the material models. The material models created from the compatibility condition in case of arbitrary strains.
3. Basic equations of mechanics in case of arbitrary strains. The „weak” version of the basic equations. Classification of the solution methods of mechanical problems from mathematical and mechanical points of view. The Veubeke-Hu-Washizu functional in general case.
4. The meaning of the curvature tensors in case of surface structures. The basic characteristics of Kirchhoff-Love and Reissner-Mindlin shell- and plate models.