BM6151

Study program / course: Mechanical Engineering				
Type and level of study: Bachelor academic studies				
Course: Finite elements 1				
Lecturers: Miroslav M. Zivkovic				
Status of course: Obligatory for modules M_5 and M_7, VI semester				
Number of ECTS: 6				
Precondition: No				
The objective of course Understanding theoretical basics of linear continuum mechanics and its application in analysis of structures using finite elements method. Introduction to a basic concept of FEM. Application of FEM in analysis of real engineering problems.				
The outcome of course Students will, upon passing exam Finite elements 1: know theoretical basics of linear continuum mechanics; understand basics of modeling and linear analysis using finite elements method; know to apply gained knowledge on modeling and linear analysis of real engineering problems.				
Syllabus **Theoretical study:** *Fundamentals of continuum mechanics:* General stress state, Cauchy formula, equilibrium equations and definition of stress. General strain state – components of strain, geometrical representation and strain tensor. Elastic and thermoelastic constitutive relations for isotropic and orthotropic materials. Generalized Hook's law, flexibility matrix and elasticity matrix, general 3-D, axisymmetric, plane strain, plane stress, shell, membrane and beam stress conditions. Transformation of constitutive relations. Principle of virtual work. *Finite element method:* General concept, interpolation functions, element matrix and structure matrix. Equilibrium of finite element system equations and boundary condition. Isoparametric finite elements. Basic 3-D element, strain-displacement matrix, elastic matrix and stiffness matrix. Strain, stress and internal force calculation. Degenerated and enhanced 3-D element. Basic, degenerated and enhanced 2-D element: axisymmetric element, plane strain element and plane stress element. Shell element, basic theoretical assumptions according Kirchhoff's and Midlin-Reissner's plate theory. Enhanced finite elements considering transversal sheers and membrane behaviours. Orthotropic multilayered shell. Axisymmetric orthotropic multilayered shell. Isoparametric beam element, basic theoretical assumptions, enhanced isoparametric beam element and curved truss element. Dynamics analysis. Numerical integration in FEM and solution of system of linear equations. Numerical methods of differential equilibrium equations of structures integration. **Practical classes** Make examples from area analysis structures by finite element methods: build the finite element model, applying constraints and loads; analysis. Post-process results - visualization of results and them interpretation.				
Recommended reading M. Kojić, R. Slavković, M. Živković. N. Grujović, Finite element methods I, Faculty of Mechanical Engineering, Kragujevac, 1998. K. J. Bathe: Finite element procedures, Prantice Hall, 1996.				
The number of hours of active teaching:				Other classes: 1
Theory: 3	Practical classes: 1.6	Other forms of teaching: 0.4	Research study: 0	
Methods of teaching Teaching is conducted through lectures, practical classes and independent work of students. Within lectures students receive basic theoretical knowledge. In practical classes students receive practical knowledge and skill for using software tools from certain areas of FEM. Students create independent tasks which include and integrate knowledge for usage of certain tools.				

Evaluation of knowledge

Pre-final exam obligations	**points**	**Final exam**	**points**
Activities during the classes:	**0**		**30**
Practical classes/ Home works:	**30**		
Colloquiums(s)/ Tests:	**40**		
Seminar(s) :			