1. Subject name	**Structure analysis**				
2. Subject name in Hungarian	Szerkezetanalízis				
3. Code	**BMEKOJSM609**	4. Evaluation type	**exam grade**	5. Credits	**4**
6. Weekly contact hours	**2 (10) Lecture**	**0 (0) Practice**	**2 (11) Lab**		
7. Curriculum	**Vehicle Engineering MSc (J)**	8. Role	**Mandatory (mc) at Vehicle Engineering MSc (J)**		
9. Working hours for fulfilling the requirements of the subject					**120**
Contact hours	56	Preparation for seminars	18	Homework	20
Reading written materials	12	Midterm preparation	4	Exam preparation	10
10. Department	**Department of Railway Vehicles and Vehicle System Analysis**				
11. Responsible lecturer	Dr. Béda Péter				
12. Lecturers	Dr. Béda Péter, Devecz János				
13. Prerequisites					

14. Description of lectures

Notion of numerical structure analysis. Numerical model generation from a geometrical model. Theory and application of the finite element analysis in the vehicle technology. Theoretical background of the finite element analysis method (FEA). Improvement of the solution using discretization and polynomial degree increase, method of p-elements and h-elements. Material models: linear, elasto-plastic and hyperelastic ones. Structure of finite element models. Simplification possibilities of geometrical models. Geometry discretisation: mesh generation, notion of mesh independence. Structure of a stiffness analysis: load types, forces, torques, bearing-like loads. Constraints: ideally stiff constraints, elastic constraints. Evaluation of deformation and stress fields. The Galerkin method. Elliptical and parabolic partial differential equations and their solutions. Eigenvalue exercises. The Navier equation and the convection-diffusion energy equation. Matrices of the discretized equations (mass, damping, stiffness). Unicity conditions of the result, initial and limit conditions. Structure of a thermal (convective-diffusive) analysis. Load types, heat sources, convection, heat radiation. Constraints, fixation of temperatures and gradients. Evaluation of temperature and thermal flux fields. Structure of a natural frequency analysis. Evaluation of natural frequencies and vibration modes. Application of FEA for lifetime optimisation for load varying in time. Bases of structure optimisation (size, shape, topology) theory. Methods for gradient free optimum seeking in the structure optimization. Model building, setup of design variables, parameters and conditions. Evaluation of the optimization result. New model building from the result of the optimization process. Consideration of ability for manufacturing and realisation. Application of reverse engineering methods during rebuilding the model. Comparative FEA of the original and the optimised model.

15. Description of practices

16. Description of labortory practices

Guided and individual problem solving

17. Learning outcomes

A. Knowledge

- the student knows the finite elements theory and the model building
- knows the limits of the approximative solution and methods to increase precision
- knows the various material models and their application
- knows the methods for loading and constraining
- knows the mathematical background of the solution and the convergence properties
- knows the variuos modeling techniques to extract a given physical quantity as result
- knows methods for part optimisation

B. Skills

- the student is able to build a finite elements model that suits the geometry of the given structure
- is able to build up a model that produces the results that have to be studied
- is able to get a result with required precision and to estimate its plausibility
- is able to optimize the model upon the given conditions
- is able to create a new geometry based on the optimisation results
- is able to evaluate the realized work upon the numerical results

C. Attitudes

- the student makes an effort to gather all the available informations in a given domain
- Cooperates with his fellow students and the teacher
- is open minded towards new and innovative ideas and researches
- uses informatical and computational devices for his work

D. Autonomy and Responsibility

- the student is conscient about his responsibility towards the society and his company
- asks for the colleagues' expertise and judgement when working
- considers challenges with responsibility

18. Requirements, way to determine a grade (obtain a signature)

For signature: determined points from 1 semestrial project (teamwork), 1 non-compulsory test, 1 shorter homework. Final grade equals to the result of the exam.

19. Opportunity for repeat/retake and delayed completion

Second test possibility for those not present on the test, possibility of delayed deadline for project work

20. Learning materials

Slides and examples in electronic format

Effective date	10 October 2019	**This Subject Datasheet is valid for**	Inactive courses