Final exam questions

Subject group name: **Nonlinear Vibrations**

Neptun code: ZVEGEMMNWVI

Credit points: 3

Subject in this subject group:

Nonlinear Vibrations (BMEGEMMNWVI)

Program: Mechanical Engineering Modelling, MSc (2N-MW0)

Specialization: Solid Mechanics

Responsible person: Dr. Gábor Stépán, stepan@mm.bme.hu
Department of Applied Mechanics
Faculty of Mechanical Engineering

You can check the current subject forms at the Educational Portal of the Faculty of Mechanical Engineering.

https://oktatas.gpk.bme.hu/

Always check the for updates at edu.gpk.bme.hu before preparing for the exam, especially if the subject group contains at least one subject from your final semester!

Valid from 01 September 2021

Dr. Gábor Stépán
full professor

Nonlinear Vibrations (BMEGEMMNWVI)

1. Typical nonlinearities in mechanical oscillatory systems, their mathematical description. Structure of differential equations of nonlinear one degree of freedom mechanical systems.

2. Phase plane method for nonlinear one degree of freedom systems. Equilibria, local linearization, classification of local phase portraits, topological methods in the phase plane. Basic types of loss of stability, saddle-node, and Hopf-bifurcation.

3. Equilibria in one degree of freedom conservative systems. Pitchfork bifurcation, the basic idea of catastrophe theory. Construction of phase portraits based on the potential function.

4. Estimation of the time period of large amplitude oscillations in conservative systems. Linearization methods, Poincaré's asymptotic method. Change of the time period of oscillation in cases of progressive and degressive spring characteristics.

5. Construction of the phase portrait in nonlinear dissipative systems. Liénard's phase-plane method. Damped oscillations in the phase plane for different damping characteristics. Phase portrait and non-uniqueness of the solutions for Coulomb friction.

6. Nonlinear forced oscillations. Resonance diagram (forced vibration amplitude against excitation frequency) for hardening and softening spring characteristics and harmonic excitation. Application of Poincaré's small parameter method.

7. Self-excited vibration and the idea of the limit cycle. Linénard's criterion for the sufficient condition of the existence of limit cycles, Bendixson's criterion for the necessary condition of the existence of limit cycles. The phenomenon of stick-slip.

8. Hopf bifurcation theorem for the necessary and sufficient condition of the existence of limit cycles, approximation of the limit cycle. Supercritical and subcritical bifurcations. Application for stick-slip, the phenomenon of unstable self-excited oscillation and its relevance in engineering practice.