Tárgytematika / Course Description
Vibrations

GKNB_AMTA005

Tárgyfelelős neve / Teacher's name: dr. Pidl Renáta Rita
Félév / Semester: 2025/26/1
Beszámolási forma / Assesment: Vizsga
Tárgy heti óraszáma / Teaching hours(week): 2/2/0
Tárgy féléves óraszáma / Teaching hours(sem.): 0/0/0

OKTATÁS CÉLJA / AIM OF THE COURSE

Understanding the fundamental concepts of vibration theory. Writing the equations of motion for single and multi-degree-of-freedom vibrating systems using the Lagrange equation of the second kind. Solving the equation of motion for single-degree-of-freedom free vibrating systems. Time- and frequency-domain analysis of single-degree-of-freedom forced vibrating systems, including plotting resonance curves. Modal analysis of undamped multi-degree-of-freedom vibrating systems, along with time- and frequency-domain analysis. Understanding the longitudinal, torsional, and bending vibrations of rods as continuous systems.

TANTÁRGY TARTALMA / DESCRIPTION

Témakör név: Fundamental Concepts of Vibration Theory

Témakör leírása: Overview of the mathematical tools used in vibration theory (complex numbers, matrix algebra). Basic concepts of vibration theory: vibration, spring, damping, excitation. Classification of vibrations.
Témakör kulcsszavai: complex numbers, matrix algebra, vibration, spring, damping, excitation

Témakör név: Lagrange Equation of the Second Kind

Témakör leírása: Application of the Euler-Lagrange equation to mechanical problems: the Lagrange equation of the second kind. Introduction of generalized coordinates. Determination of generalized forces from system performance and potential. Comparison of the Lagrange and Newton methods.
Témakör kulcsszavai: Lagrange equation of the second kind, kinetic energy, potential energy, conservation of energy, Hamilton's principle, Rayleigh’s dissipative potential

Témakör név: Single-Degree-of-Freedom Vibration Systems

Témakör leírása: Writing the equation of motion for single-degree-of-freedom vibrating systems using the Lagrange equation of the second kind. Determining the reduced mass, reduced damping factor, and reduced stiffness.
Témakör kulcsszavai: single-degree-of-freedom vibration system, reduced mass, reduced damping factor, reduced stiffness

Témakör név: Excitation of Vibration Systems

Témakör leírása: Taking the mass of the springs into account. The most common cases of excitation: prescribed force, torque, prescribed displacement, angular displacement.
Témakör kulcsszavai: excitation with force, excitation with torque, base excitation

Témakör név: Solution of the Equation of Motion for Free, Undamped Vibration Systems
Témakör leírása: Solution of the equation of motion for a single-degree-of-freedom, undamped, free system. The system's natural frequency.
Témakör kulcsszavai: free vibration, natural frequency, period

Témakör név: Solution of the Equation of Motion for Free, Damped Vibration Systems
Témakör leírása: Solution of the equation of motion for a single-degree-of-freedom, damped, free system. Representation of the vibration using a rotating complex vector diagram. Periodic and aperiodic solutions. Characterization of the degree of damping with logarithmic decrement. Determination of system characteristics based on measurements.
Témakör kulcsszavai: damped free vibration, undamped natural angular frequency, damped natural angular frequency, Lehr damping ratio, critical damping, overdamping, system pole, logarithmic decrement

Témakör név: Time-Domain Analysis of Forced Vibration Systems
Témakör leírása: Solution of the equation of motion for a single-degree-of-freedom, damped, harmonically forced system. Introduction of dynamic stiffness. Full and stationary solutions. Representation of the stationary solution on a complex rotating vector diagram. Writing displacement, velocity, and acceleration functions in both complex and scalar form. Determining the maximum forces in the spring and damper.
Témakör kulcsszavai: forced vibration, dynamic stiffness, stationary solution, phase lag

Témakör név: Frequency-Domain Analysis of Forced Vibration Systems
Témakör leírása: Investigation of maximum displacements as a function of the excitation frequency: real and imaginary parts of the frequency response function, as well as amplitude and phase lag. Determination of resonance frequency. Vibration isolation of machines and equipment.
Témakör kulcsszavai: frequency response function, Bode diagram, resonance curve, frequency ratio, resonance frequency, vibration isolation

Témakör név: Writing the Equations of Motion for Multi-Degree-of-Freedom Vibration Systems
Témakör leírása: Writing the equations of motion for multi-degree-of-freedom vibrating systems using the Lagrange equation of the second kind. Generation of mass matrix, stiffness matrix, damping matrix, and excitation force vector. Formulating the matrix coefficient differential equation.
Témakör kulcsszavai: multi-degree-of-freedom vibration systems, mass matrix, stiffness matrix, damping matrix, excitation force vector

Témakör név: Modal Analysis
Témakör leírása: Determining the natural frequencies and mode shapes of undamped multi-degree-of-freedom vibrating systems using the generalized eigenvalue problem.
Témakör kulcsszavai: modal analysis, natural frequency, mode shape, generalized eigenvalue problem

Témakör név: Multi-Degree-of-Freedom Vibration Systems – Time-Domain Solution
Témakör leírása: Normalization of mode shape vectors with respect to mass. Transformation of the equation of motion of an undamped multi-degree-of-freedom vibrating system from global coordinates to modal coordinates. Time-domain solution.
Témakör kulcsszavai: global coordinate, modal coordinate, modal matrix

Témakör név: Multi-Degree-of-Freedom Vibration Systems – Frequency-Domain Solution
Témakör leírása: Matrix of the frequency response function for undamped multi-degree-of-freedom vibrating systems. Frequency response function from the dynamic stiffness matrix.
Témakör kulcsszavai: frequency response function matrix, dynamic stiffness matrix

Témakör név: Longitudinal and Torsional Continuum Vibrations of Rods
Témakör leírása: Longitudinal and torsional continuum vibrations of rods. Determination of natural frequencies

and mode shapes.
Témakör kulcsszavai: longitudinal continuum vibration, torsional continuum vibration, natural frequency, mode shape

Témakör név: Bending Continuum Vibrations of Rods
Témakör leírása: Bending continuum vibrations of rods. Determination of natural frequencies and mode shapes.
Témakör kulcsszavai: bending continuum vibration, natural frequency, mode shape

Tevékenység típusok

Kontakt előadás
Mérték: 28 tanóra (hour)
Leírás: Vibrations lecture
Kötelező: Nem
Becsült Idő: 28 óra

Kontakt gyakorlat
Mérték: 28 tanóra (hour)
Leírás: Vibrations practice
Kötelező: Nem
Becsült Idő: 28 óra

Otthoni gyakorlás
Mérték: 1 db (PCS)
Leírás: Preparation for midterm tests / final exam
Kötelező: Nem
Becsült Idő: 90 óra

SZÁMONKÉRÉSI ÉS ÉRTÉKELÉSI RENDSZERE / ASSESMENT'S METHOD

Számonkérési forma:
Vizsga (Exam)

Kötelező félévközi zárthelyik (oktató által javított)
Mérték: 2 db (PCS)
Leírás: Two midterm tests, each 50 minutes long
Kötelező: Igen
Becsült Idő: 2 óra

Vizsga írásbeli része
Mérték: 1 db (PCS)
Leírás: 100-minute written exam
Kötelező: Nem
Becsült Idő: 2 óra

Aláírás kialakításának módja:

The conditions of the signature are • attendance at at least 80% of the lectures and seminars (counted separately, maximum 3-3 absences), • achieving 10-10 points on each of the two tests, worth a maximum of 20-20 points each, • and successful completion of the online assignment set by the lecturer.

Érdemjegy kialakításának módja:

If a signature is obtained, a maximum of 40 points from the tests, 20 points from class attendance, and 10 points from the online assignment can be carried over to the exam. A maximum of 80 points can be obtained in the written exam, to which a maximum of 70 midterm points can be added. The condition for passing the exam is to obtain 90 points (60%) out of a total of 150 points, including 32 points from the exam paper. In the case of a successful exam, the minimum thresholds for the individual grades are as follows: 90 pts. (60%): satisfactory (2) 105 pts. (70%): average (3) 120 pts. (80%): good (4) 135 pts. (90%): excellent (5)

KÖTELEZŐ IRODALOM / OBLIGATORY MATERIAL

Égert J. – Jezsó K.: Mechanics - Vibrations, Universitas-Győr Kht. 2006.

M. Csizmadia B. - Nándori E.: Mechanics for engineers – Dynamics, Nemzeti Tankönyvkiadó, 1999.

D. Thorby: Structural Dynamics and Vibration in Practice: An Engineering Handbook, Butterworth-Heinemann, Boston, 2008.

AJÁNLOTT IRODALOM / RECOMMENDED MATERIAL

Douglas Thorby: Structural Dynamics and Vibration in Practice: An Engineering Handbook (2008), Butterworth-Heinemann ISBN: 978-0-7506-8002-8 https://www.sciencedirect.com/book/9780750680028/structural-dynamics-and-vibration-in-practice

Michael R. Hatch: Vibration Simulation Using MATLAB and ANSYS (2001), Chapman & Hall/CRC ISBN: 1-58488-205-0 https://www.mathworks.com/academia/books/vibration-simulation-using-matlab-and-ansys-hatch.html

Balakumar Balachandran, Edward B. Magrab: Vibrations (2018), Cambridge University Press ISBN: 978-1108427319 https://www.cambridge.org/highereducation/books/vibrations/D77B34F1320BDC1EAE74CCF5117E77C6

S. Graham Kelly: Mechanical Vibrations Theory and Applications (2022), Cognella Academic Publishing ISBN: 978-1793523136 https://titles.cognella.com/mechanical-vibrations-9781793523136

S. Graham Kelly: Fundamentals of Mechanical Vibrations (2000), McGraw Hill ISBN: 978-0072300925 https://www.abebooks.co.uk/9780072300925/Fundamentals-Mechanical-Vibrations-Graham-Kelly-0072300922/plp

Singiresu S. Rao: Mechanical Vibrations (2021), Pearson ISBN: 9780137515288 https://www.pearson.com/en-us/subject-catalog/p/mechanical-vibrations/P200000003425/9780137515288