



Valid from 2026.HS

Module description: Physics 3: Mechanical Vibrations	
Module Code	t.BA.MTP.PHY3.26HS
ECTS Credits	4
Language of Instruction/Examination	German
Organizational Unit	IMES
Module Coordinator	Mario Weder
Legal Framework	The module description is part of the legal basis in addition to the general academic regulations. It is binding. During the first week of the semester a written and communicated supplement can specify the module description in more detail.
Module Characteristic	Type 3a 2 lecture lessons per semester week and class+ 2 weekly lab lessons per semester and half-class
Module Description	Physics 3 introduces the fundamentals of dynamical systems in Mechanical Engineering. Building upon the principles of dynamics, you will learn to calculate the motion of mechanical systems under the influence of forces and constraints. The module focuses on the dynamics of rigid body systems and the theory of vibrations.

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<p>Module Content</p>	<p>Elementary Concepts (2D)</p> <ul style="list-style-type: none"> • Mechanical model, rigid body, position vector, orientation, velocity, acceleration, • Projection of velocities, instant center of motion • Linear and angular momentum, moment of inertia, parallel axis theorem, balance of linear and angular momentum, balance of spin, force laws, classification of forces, degree of freedom <p>Linear Oscillations (f = 1)</p> <ul style="list-style-type: none"> • Fundamental problem with excitation by force and displacement, equation of motion, state form, dimensionless form, damping ratio, general, particular and homogenous solution • Discussion of homogenous solution (free oscillations), exponential ansatz, discussion of eigenvalues, undamped case ($D = 0$), eigenfrequency, subcritical case ($0 < D < 1$), logarithmic decrement, critical case ($D = 1$), supercritical case ($D > 1$), limit case ($D \rightarrow \infty$), comparison of transient response • Discussion of particular solution (harmonic excitation), complex stiffness, complex compliance, amplitude and phase response • Discussion general solution <p>Kinematics in Space</p> <ul style="list-style-type: none"> • Vectors space, coordinate system, vector and components, coordinate transformation • Elementary rotations, rotation between coordinate systems, time derivative of vectors in rotating coordinate systems (Euler derivative) • Kinematic quantities of a rigid body, computation of velocities and accelerations, rigid body formulas <p>General Kinetics</p> <ul style="list-style-type: none"> • Mechanical system, internal and external forces, general law of interaction, dynamic equilibrium, balance of linear and angular momentum, resulting forces and inertia terms <p>Kinetics of Rigid Body</p> <ul style="list-style-type: none"> • Rigid body, mass, inertia tensor, kinetic energy of rigid body, transformation laws for inertia tensor, evaluation of linear and angular momentum, time derivative of linear and angular momentum, balance of linear and angular momentum <p>Sustainable Development Goals</p> <ul style="list-style-type: none"> • In this module, students learn the fundamentals of dynamics required for the analysis and development of dynamic systems. Example applications include vibrations in rotating machines in energy supply, the driving behavior of rail vehicles, and the use of quartz crystals in measurement technology. This module thus contributes to future innovation and a resilient infrastructure in line with SDG 9.
<p>Prerequisite Knowledge</p>	<p>Statics: Free body diagram, forces, law of interaction (actio = reactio), equilibrium equations</p> <p>Analysis 1: Differentiation, derivative as the limit of the difference quotient, product rule, quotient rule, chain rule (inner derivative)</p> <p>Analysis 2: Cosine and sine functions</p> <p>Algebra and statistics 1: Vectors as geometric objects (arrows), magnitude of a vector, scalar product, cross product</p> <p>Algebra and statistics 2: Matrix multiplication, inverses, transposes</p> <p>Analysis 3: Complex numbers, ordinary differential equations, surface and volume integrals</p>

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Learning Objectives (Competencies)	Students...		Competencies	Taxonomies		
	[LO] can derive and interpret the motion for models consisting of rigid bodies, ideal constraints, elementary force elements, and external excitation.		F, M, SE	K4		
	[LO.1] recognize a system's ability of motion and describe its kinematics.		F, M	K3		
	[LO.2] can draw the system's free-body diagram and apply the reaction forces.		F, M	K3		
	[LO.3] can formulate force laws for elementary force elements (spring, dashpot)		F, M	K3		
	[LO.4] can formulate the balance of linear and angular momentum (or spin) for rigid bodies.		M, F	K3		
	[LO.5] can reduce the differential equations from linear and angular momentum to the system's equations of motion.		F, M	K3		
[LO.6] can solve and interpret the equations of motion using appropriate methods (analytical/numerical).		M, F	K3			
Performance Assessment	End-of-module exam	Assessment	Length (min.)	Weighting	Social Form	Scenario/Format
	written exam	Grade	90	80%	acc. to module agreement	
		Assessment	Length (min.)	Weighting	Social Form	Scenario/Format
	written exam	Grade	45	20%	acc. to module agreement	
Classroom Attendance Requirement	None					
Learning material	<ul style="list-style-type: none"> Lecturer-specific 					
Comments	<p>Supplementary literature:</p> <ul style="list-style-type: none"> Markert, R. (2013). Dynamik – Teil B der Technischen Mechanik. Shaker Verlag. Markert, R. (2013) Dynamik – Aufgaben. Shaker Verlag. Baumann, K. und Markert, R. (2021) Dynamik – Aufgaben – Band 2. Shaker Verlag. Hagedorn, P. und Wallaschek, J. (2017). Technische Mechanik – Band 3: Dynamik. Edition Harry Deutsch. Hagedorn, P. und Wallaschek, J. (2015). Technische Schwingungslehre – Schwingungen linearer diskreter mechanischer Systeme. Edition Harry Deutsch. 					