#### Applied Dynamics

Code: MK5ADING05GX17-EN

ECTS Credit Points: 5

Evaluation: exam

Year, Semester: 1st fall semester

Its prerequisite(s): -

Further courses are built on it: Yes/No

Number of teaching hours/week (lecture + practice): 2+3

Topics:

Linear and nonlinear dynamical system analysis in time-domain. Differential equations. Duhamel principle and transfer function. Convolution. Typical signals for system analysis. Harmonic functions as input signals for dynamical systems. Ergodic excitations. Dirac and Heaviside functions. Transfer characteristics. Stochastic signals and environmental vibrations on dynamic systems. Autocorrelation function and cross-correlation function. Hamilton-Jacobi equations. Virtual work principle. D'Alembert principle. Classification of the constraints. First order Lagrange equation.

Second order Lagrange equation. Holonomic and nonholonomic constraints.

Generalization of Lagrange principle for 1-DOF and higher DOF dynamic systems.

Analysis of linear systems in complex frequency domain. Integral transformations for analysis of mass-spring-damper systems. Laplace transform for mathematical solution of DEs and for analysis of mass-spring-damper systems. Asymptotic principles. Stability of linear systems. Nyquist criteria Routh-Hurwitz criteria.

Analysis of linear systems in frequency domain. Fourier integral. Fourier transform. Analysis of signals and systems by Fourier transform. Bending vibrations of power transmission systems. Simulation in Matlab, Labview and Simulink. Continuum vibrations. Torsional vibrations of shafts. Laval-rotor. Rayleigh quotient iteration, Stodola (convergence), Rayleigh's principle, Dunkerley's estimate. Longitudinal and torsional vibrations of prismatic bars.

Vibration of continuum bars The Sturm-Liouville task and relationship with the standing wave solution. Longitudinal vibrations of prismatic beams.

Spatial mechanisms. Robot manipulators. Kinematics and dynamics of wrist movements, kinematic chains, Lagrange equations, TTT / RTT / RRR work spaces. Robotics in machine industry.

Spatial mechanisms direct and inverse kinematic and dynamic characterization tasks, Lagrange equations. Denavit-Hartenberg principle. Grashof principle and Roberts principle for spatial mechanisms. Simscape simulation for spatial mechanisms.

Vibration analysis of cutting machines in manufacturing technology, spindles, rotors as special dynamic systems. Simulations of dynamic systems in Matlab Simulink. Vibration isolation systems, calculation, vibration reduction, critical frequency, resonance, environmental noise and vibration reduction methods.

Literature:

Compulsory:

* Allan G. Piersol, Thomas L.Paez: Harris’s Shock and Vibration Handbook, Sixth Edition, McGrraw-Hill,2010. ISBN 978-0-07-163343-7
* S. Graham Kelly: Mechanical Vibrations Theory and Applications, University of Akron, 2012. ISBN -13: 978-1-4390-6214-2
* Harold Josephs- Ronald J. Huston: Dynamics of mechanical systems. 5th Edition, CRC Press Inc., 2006. ISBN 0-8439-0593-4
* Parasuram Harihara, Dara W. Childs: Solving Problems in Dynamics and Vibrations Using MATLAB, Dept. of Mechanical Engineering, Texas, A & M University, 2014
* Eugene Avallone: Standard Handbook for Mechanical Engineers, Eleventh Edition, McGrraw-Hill,2010. ISBN-13: 978-0-07-142867-5

Schedule

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| 1st week: Registration week |  |
| 2nd week:  Lecture: Mathematical basics. Matrices. Tensors. Diff. equations. Eigenvalues. Numerical methods.  Practice: Matlab applications. | 3rd week:  Lecture: Linear and nonlinear dynamical system analysis in time-domain. Differential equations. Duhamel principle and transfer function. Convolution.  Typical signals for system analysis. Harmonic functions as input signals for dynamical systems. Ergodic excitations.  Practice: Differential equations and calculations. |

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| 4th week:  Lecture: Dirac and Heaviside functions. Transfer characteristics. Stochastic signals and environmental vibrations on dynamical systems. Autocorrelation function and cross-correlation function Practice:  Labview and Matlab signal generation for system analysis. | 5th week:  Lecture: Hamilton-Jacobi equations. Virtual work principle. D'Alembert principle. Classification of the constraints. First order Lagrange equation.  Second order Lagrange equation.  Holonomic and nonholonomic constraints.  Practice: Lagrange equations for dynamical systems. Solution of Diff. equations. |
| 6th week:  Lecture: Generalization of Lagrange principle for 1-DOF and higher DOF dynamic systems.  Practice:  Examples and calculations of 1-DOF and higher DOF mass-damper-spring systems. | 7th week:  Lecture: Analysis of linear systems in complex frequency domain. Integral  transformations for analysis of mass-springdamper systems. Laplace transform for mathematical solution of DEs and for analysis of mass-spring-damper systems.  Practice: Laplace transform applications for dynamic systems. |
| 8th week: 1st drawing week |  |
| 9th week:  Lecture: Analysis of linear systems in frequency domain. Fourier integral. Fourier transform. Analysis of signals and systems by Fourier transform. Stability of linear systems. Nyquist criteria Routh-Hurwitz criteria.  Practice: Analysis of harmonic signals with Fourier transform. | 10th week:  Lecture: Bending vibrations of power transmission systems. Laval-rotor. Rayleigh quotient iteration, Stodola convergence, Rayleigh's principle, Dunkerley's estimate. Longitudinal and torsional vibrations of prismatic bars.  Vibration of continuum bars The Sturm-  Liouville task.  Practice: Simulation in Matlab, Labview and Simulink. |
| 11th week:  Lecture: Spatial mechanisms. Robot manipulators. Kinematics and dynamics of wrist movements, kinematic chains, Lagrange equations, TTT / RTT / RRR work spaces. Robotics in machine industry. | 12th week:  Lecture: Spatial mechanisms DenavitHartenberg principle. Grashof principle and Roberts principle for spatial mechanisms.  Practice: Simulation in Simulink and Labview. |
| Spatial mechanisms direct and inverse kinematic and dynamic characterization tasks, Lagrange equations.  Practice: Simscape simulation for spatial mechanisms.  13th week:  Lecture: Vibration analysis of cutting machines in manufacturing technology, spindles, rotors as special dynamic systems.  Practice: Simulations of dynamic systems in Matlab Simulink. | 14th week:  Lecture: Vibration isolation systems, calculation, vibration reduction, critical frequency, resonance, environmental noise and vibration reduction methods.  Practice: Passive and active vibration isolation system calculations. Vibration measurement and methods for mitigation. |
| 15th week: 2nd drawing week |  |

Requirements

A, for a signature:

Participation at practice classes is compulsory. Students must attend practice classes and may not miss more than three practice classes during the semester. In case a student does so, the subject will not be signed and the student must repeat the course. Students can’t take part in any practice class with another group. Attendance at practice classes will be recorded by the practice leader. Being late is equivalent with an absence. In case of further absences, a medical certification needs to be presented. Missed practice classes must be made up for at a later date, being discussed with the tutor.

During the semester there are two tests: the mid-term test is on the 8th week and the end-term test is on the 15th week. Students must sit for the tests.

B, for grade:

The course ends in exam grade. The grade for the test is given according to the following (score/grade): 0-59 % = fail (1); 60-69 % = pass (2); 70-79 % = satisfactory (3); 80-89 % = good (4); 90-100 % = excellent (5).

#### Applied Thermodynamics and Fluid Mechanics

Code: MK5AHOAL04GX17-EN

ECTS Credit Points: 4

Evaluation: mid-semester grade

Year, Semester: 1st spring semester

Its prerequisite(s): -

Further courses are built on it: Yes/No

Number of teaching hours/week (lecture + practice): 2+2

Topics:

Similarity rules, wind tunnels; Navier-Stokes equation, turbulency models; Meshing of the fluid flow; Isotherm flow modelling; Variable temperature flow modelling; Rotating flow modelling; Non-stationary flow modelling; Multi-source flow modelling; Multi-phase flow modelling; Multi-phase flow thermal modelling; Multi-phase flow thermal modelling; Multi-phase flow thermal modelling

Literature:

Compulsory:

* Yunus A. Çengel, John M. Cimbal Boston : McGraw-Hill Higher Education, cop. 2010 Fluid mechanics: fundamentals and applications ISBN: 9780073529264 Recommended:
* <https://support.ansys.com/portal/site/AnsysCustomerPortal>guides on the web page

Schedule

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| --- | --- |
| 1st week: Registration week |  |
| 2nd week:  Lecture: Similarity rules, wind tunnels  Practice: The practical application of the theoretical curriculum said during the lecture. | 3rd week:  Lecture: Navier-Stokes equation, turbulency models  Practice: The practical application of the theoretical curriculum said during the lecture. |
| 4th week:  Lecture: Meshing of the fluid flow | 5th week:  Lecture: Isotherm flow modelling |
| Practice: The practical application of the theoretical curriculum said during the lecture. | Practice: The practical application of the theoretical curriculum said during the lecture. |
| 6th week:  Lecture: Variable temperature flow modelling  Practice: The practical application of the theoretical curriculum said during the lecture. | 7th week:  Lecture: Rotating flow modelling  Practice: The practical application of the theoretical curriculum said during the lecture. |
| 8th week: 1st drawing week |  |
| 9th week:  Lecture: Non-stationary flow modelling  Practice: The practical application of the theoretical curriculum said during the lecture. | 10th week:  Lecture: Multi-source flow modelling  Practice: The practical application of the theoretical curriculum said during the lecture. |
| 11th week:  Lecture: Multi-phase flow modelling  Practice: The practical application of the theoretical curriculum said during the lecture. | 12th week:  Lecture: Multi-phase flow thermal modelling  Practice: The practical application of the theoretical curriculum said during the lecture. |
| 13th week:  Lecture: Individual problem solving  Practice: The practical application of the theoretical curriculum said during the lecture. | 14th week:  Lecture: Exam |
| 15th week: 2nd drawing week |  |

Requirements

A, for signature:

Attendance on the lectures is compulsory.

Student must attend on the lecture and may not miss more than three lectures during the semester. In case a student misses more than three, the subject will not be signed and the student must repeat the course. Being late is counted as an absence. In case of further absences, a medical certificate needs to be presented. Active participation is evaluated by the teacher in every class. If student’s behaviour or conduct doesn’t meet the requirements of active participation, the teacher may evaluate their participation as an absence due to the lack of active participation in class.

B, for grade:

The course ends with midterm grade. From the theory mid-term test will be written too. Based on the 2 practice test results and the theory test the mid-semester grade is calculated as an average of them.

The minimum requirement for all the tests is 50%. Based on the score of the tests separately, the grade for the tests is given according to the following (score/grade): 0-50 % = fail (1); 51-60 % = pass (2); 61-74 % = satisfactory (3); 75-89 % = good (4); 90-100 % = excellent (5).