Dynamics and Vibrations

Code: MK3MREZG04GX17-EN

ECTS Credit Points: 4

Evaluation: mid-semester grade

Year, Semester: 2nd year, 4th semester

Its prerequisite(s): Strength of Materials

Further courses are built on it: Yes/No

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

Topics:

Motion of a particle:

position, velocity and acceleration and the mathematical relations between them, description of the motion of the particle in Cartesian coordinate system and Frenet-frame, Newton's laws and differential equation of the motion of the particle, theorems of kinetics, force fields, kinetic, potential and mechanical energy, constrained motion along a two or three dimensional curve

Motion of a rigid body:

description of the translational, rotational and general plane motion of a rigid body, concept and determination of the instantaneous centre of zero velocity and acceleration, rolling motion without slipping, description of the plane motion of a rigid body in a time interval, centre of mass, momentum and angular momentum, moment of inertia and its calculation, mechanical work, Newton's laws and theorem of kinetics for rigid bodies, rotating and swinging of the body about an axis, rolling without slipping

Vibrations:

Description and classification of vibratory motions and vibrating systems. Basic definitions and properties of vibratory motion. Investigation of the elements of vibrating systems: masses and inertial elements, flexible and damping elements. Investigation of the dynamic models. Two ways for the generation of motion equations: the D'Alembert's principle and the Lagrange equations of motion. Investigation and properties of the free vibrations of single DOF undamped and damped systems. Solution of the homogenous motion equation. Investigation and properties of the forced vibrations of single DOF undamped and damped systems. Basic types of forced vibrating systems. Multiple DOF systems: introduction, basic properties, natural frequencies and modes, modal transform and decoupling.

Literature:

Compulsory:

- Russel C. Hibbeler: Engineering Mechanics – Statics and Dynamics, Prentice Hall, 2006. ISBN-13 9780132215091
- Jerry Ginsberg: Engineering Dynamics, 3rd edition, Cambridge University Press, 2007. ISBN-13: 978-0521883030
- Lakshmana C. Rao, J. Lakshminarasimhan, Raju Sethuraman, Srinivasan M. Sivakumar: Engineering Mechanics: Statics and Dynamics, PHI Learning Pvt. Ltd., 2004. ISBN 8120321898, 9788120321892
- Meirovitch, Leonard: Fundamentals of Vibration, McGraw-Hill Publishing Company, 2000. ISBN 0071181741

Recommended:

- Ferdinand P. Beer, E. Russell Johnston, Jr.: University of Connecticut, Mechanics for Engineers: Statics and Dynamics (Package), 4th Edition, ©1987, ISBN-13 9780070045842

- Joseph F. Shelley: 700 solved problems in vector mechanics for engineers, Volume II: Dynamics. (SCHAUM'S SOLVED PROBLEM SERIES), McGraw-Hill, 1990. ISBN 0-07-056687-9

Schedule

1st week Registration week	
2nd week: Lecture: Kinematics of a particle Scalar and vector position, velocity and acceleration and the mathematical relations between them. Description of the motion in Cartesian coordinate system and Frenet-frame. Special motion types: Motion with constant acceleration, circular motion. Practice: Particle kinematics problems	3rd week: Lecture: Kinetics of a particle I Newton's laws and differential equation of the motion of the particle. Theorems of kinetics (impulse-momentum, work-energy and angular impulse-angular momentum theorems). Mechanical Power. Force fields (homogeneous, central and conservative). Kinetic, potential and mechanical energy. Practice: Particle kinetics problems I
4th week: Lecture: Kinetics of a particle II Formulas for work and potential energy in homogeneous and central force fields. Motion of the particle in gravitational and elastic spring force fields. Constrained motion along a two or three dimensional curve. Practice: Particle kinetics problems II	5th week: Lecture: Kinematics of a rigid body I Basic concepts (rigid body and disc, planar, translational, rotational and general plane motion). Connections between the velocity and acceleration of the different points of a rigid body undergoing translational, rotational and general plane motion. Instantaneous centre of zero velocity and acceleration and procedure for the determination of them with calculation and construction. Practice: Rigid body kinematics problems I
6th week: Lecture: Kinematics of a rigid body II Rolling motion without slipping. Description of the plane motion of a rigid body in a time interval. Pole curves. Practice: Rigid body kinematics problems I	7th week: Lecture: Kinetics of a rigid body I Basic concepts: centre of mass, momentum and angular momentum, moment of inertia and its calculation, parallel axis theorem, mechanical work. Practice: Rigid body kinetics problems I
8th week: 1st drawing week	
9th week: Lecture: Kinetics of a rigid body II Newton's laws and theorem of kinetics for rigid bodies (impulse-momentum, angular impulse-angular momentum and work-energy theorems). Special motion types: Rotating and swinging about an axis, rolling without slipping. Practice: Rigid body kinetics problems II	10th week: Lecture: Description and classification of vibratory motions and vibrating systems. Basic definitions and properties of vibratory motion. Investigation of the elements of vibrating systems: masses and inertial elements, flexible and damping elements. Practice: Reduction of masses. Replacement of rigid bodies by lumped masses. Reduction of springs and damping elements.
11th week:	12th week:

Lecture: Investigation of the dynamic models. Two ways for the generation of motion equations: the D'Alembert's principle and the Lagrange equations of motion. Practice: Generating the equations of motion for single- and multiple degrees of freedom (DOF) systems.	Lecture: Investigation and properties of the free vibrations of single DOF undamped and damped systems. Solution of the homogenous motion equation. Practice: Calculation problems related to the free vibrations of single DOF undamped and damped systems.
13th week: Lecture: Investigation and properties of the forced vibrations of single DOF undamped and damped systems. Basic types of forced vibrating systems. Practice: Calculation examples of several kinds of forced vibrations in case of single DOF undamped and damped systems.	14th week: Lecture: Multiple DOF systems: introduction, basic properties, natural frequencies and modes, modal transform and decoupling. Practice: Calculation problems related to the free and forced vibrations of multiple DOF undamped and damped systems.
15th week: 2nd drawing week	

Requirements

A, for a signature:

Attendance on the **lectures** is recommended, but not compulsory.

Participation at **practice** is compulsory. Student must attend the practices and may not miss more than three practices during the semester. In case a student misses more than three, the subject will not be signed and the student must repeat the course. Student can't make up a practice with another group. The attendance on practice will be recorded by the practice leader. Being late is counted as an absence. In case of further absences, a medical certificate needs to be presented. Missed practices should be made up for at a later date, to be discussed with the tutor.

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

B, for grade:

The course ends in **mid-semester grade** based on the average grade of the two tests.

The minimum requirement for the mid-term and end-term tests is 60%. Based on the score of the tests separately, the grade for the tests is given according to the following table:

Score	Grade
0-59	fail (1)
60-69	pass (2)
70-79	satisfactory (3)
80-89	good (4)
90-100	excellent (5)

If the score of any test is below 60, the student once can take a retake test covering the whole semester material.