Module DDM 4205 - Integrity of Structures

1	Module Number	Study Program	Semester	Offered in	Duration	Module Type	Workload (h)	ECTS Points
	4205	DDM	1	☒WS ☐SS	1 Semester	compulsory	180	6

2	Courses	Teaching and Learning Forms	Contact Time (SWS)	Contact Time (h)	Self-Study Time (h)	Language
	a) Integrity of Structures	Lecture with Laboratory	4	40	110	English
	b) Failure Analysis:	Lecture with Laboratory	2	30		

3 **Learning Outcomes and Competences**

Once the module has been successfully completed, the students can...

Knowledge and Understanding

- Understand the advanced concepts to evaluate the operational safety and integrity of engineering/car structures under static and cyclic loading
- Understand and explain the procedure for a life-time-assessment of components under variable amplitude loading.
- Basic knowledge about fatigue behaviour under complex multiaxial loading
- Understand principles and methodology of failure investigation
- Explain typical failure patterns and failure modes of engineering structures
- Understand reasons, characteristics and types of failures.

Use, Application and Generation of Knowledge

Use and Transfer

- Apply advanced concepts for an experimental and theoretical life-time-assessment for cyclically loaded components to real-life-problems
- Apply fracture mechanics to cracked structures under quasistatic and cyclic loading
- Calculate the life time until fatigue failure by hand for simple applications and load-time-histories
- Calculate the life time until fatigue failure using commercial software programs
- Analyse failed specimen in terms of failure cause and give technical solutions for remedies
- Create solutions how to prevent failures

Scientific Innovation

- Improve the design of safety relevant engineering structures in order to guarantee their safety and reliability under service conditions and the potential for lightweight design

Communication and Cooperation

- Interpret the results of the component safety and lifetime and draw admissible conclusions.
- Use the learned knowledge, skills and competences to evaluate the safety and integrity of engineering components and structures.
- Communicate and cooperate within the group in order to find adequate solutions for the task at hand.

Scientific Self-Conception/ Professionalism

- Derive recommendations for decisions concerning the safety of components under service loading and their release on the basis of the analyses and evaluations learnt.

4	**Contents** a) Integrity of Structures: Advanced concepts for the life-time assessment under variable amplitude loading: Nominal stress concept for cyclic loading, structural stress concept for cyclic loading, local stress concept for cyclic loading, local strain concept for cyclic loading, fracture mechanics concept Application of numerical tools for the life time prediction Selected topics / ongoing research topics: e.g. very high cycle fatigue (VHCF); fatigue behaviour of composite materials; Influence of edge conditions on fatigue behaviour, multiaxial fatigue… Laboratory exercises: Non-destructive testing, experimental determination of material and component flow curve, Neuber`s Law, Masing behaviour, local stress-strain loops, test drives with strain gauges, collecting data for load time history, numerical life time assessment b) Failure Analysis: Historical failures, typical failures at car structures, reason for failures, concepts for component optimization, definition and classification of failures, methods of failure analysis, characteristics of failures under static and cyclic mechanical, thermal and chemical loading, practical case studies and exercises
5	**Participation Requirements** Compulsory: Fundamentals of strength of materials; fundamentals of fatigue of materials, fundamentals of engineering mechanics and material science, basic knowledge of statistics Recommended: Module Strength of Materials 1, Module Strength of Materials 2 or Precourse Strength of Materials / Integrity of Structures
6	**Examination Forms and Prerequisites for Awarding ECTS Points** Written exam, 120 minutes, graded Lab reports and lab tests
7	**Further use of Module** NA
8	**Module Manager and Full-Time Lecturer** Responsible: Prof. Dr.-Ing. Peter Häfele Lecturer: Prof. Dr.-Ing. Peter Häfele, Prof. Dr.-Ing. Lothar Issler
9	**Literature** Lecture Documents Hertzberg, R. W.: Deformation and Fracture Mechanics of Engineering Materials, 6th edition, John Wiley and Sons, 2020 Dowling, N. E.: Mechanical Behavior of Materials.4th edition, Pearson, 2013 Lee, Y., Barkey, M. E., Kang, H.: Metal Fatigue Analysis Handbook: Practical Problem-solving Techniques for Computer-aided Engineering, 1st edition, Butterworth-Heinemann, 2011 Bannantine, J. A., Comer, J. J., Handrock, J. L.: Fundamentals of Metal Fatigue Analysis, Prentice Hall, 1997 Collins, J. A., Failure of Materials in Mechanical Design. Analysis, Prediction, Prevention. 2nd edition, John Wiley & Sons, 1993 FKM Guideline: Analytical Strength Assessment of Components: 6th Edition, Forschungskuratorium Maschinenbau FKM, 2012 FKM Guideline: Fracture Mechanics Proof of Strength for Engineering Components, 3rd Edition , FKM, 2009 Brett, Mc L.: Handbook of Failure Analysis of Materials in Mechanical Design: Identification, Prediction and Prevention, Auris, 1st edition, 2013 ASM-Handbook. American Society for Metals. Metals Park Ohio Vol. 9: Metallography and Microstructure. Vol. 10: Failure Analysis and Prevention Vol. 12: Fractography Vol. 19: Fatigue and Fracture Wulpi, D.J.: Understanding How Components Fail. American Society for Metals. Metals Park, 3rd edition, 2013
10	**Last Updated** 08.06.2021