TECHNISCHE UNIVERSITÄT KAISERSLAUTERN

Module Handbook (https://modhb.uni-kl.de/)

Notes on the module handbook of the department Physics

Die hier dargestellten Studiengang-, Modul- und Kursdaten des Fachbereichs Physik [PHY] befinden sich noch in Entwicklung und sind nicht offiziell.

Die offiziellen Modulhandbücher finden Sie unter https://www.physik.uni-kl.de/studium/modulhandbuecher/ (https://www.physik.uni-kl.de/studium/modulhandbuecher/) .

Module PHY-SP-6-M-7

Schwerpunktmodul Metallische Werkstoffe (M, 16.0 LP)

Module Identification

Module Number	Module Name	CP (Effort)
PHY-SP-6-M-7	*Schwerpunktmodul Metallische Werkstoffe*	16.0 CP (480 h)

Basedata

CP, Effort	16.0 CP = 480 h
Position of the semester	2 Sem. from WiSe/SuSe
Level	[7] Master (Advanced)
Language	[DE] German
Module Manager	Beck, Tilmann, Prof. Dr.-Ing. (PROF | DEPT: MV) (/staff/303/)
Lecturers	Beck, Tilmann, Prof. Dr.-Ing. (PROF | DEPT: MV) (/staff/303/) Blinn, Bastian, Dr.-Ing. (WMA | DEPT: MV) (/staff/641/) Kerscher, Eberhard, Prof. Dr.-Ing. (PROF | DEPT: MV) (/staff/316/) Liesegang, Moritz, M. Sc. (WMA | DEPT: MV) (/staff/645/) Smaga, Marek, Dr.-Ing. (WMA | DEPT: MV) (/staff/277/)
Area of study	[PHY-TECHNO] TechnoPhysics
Reference course of study	[PHY-88.B90-SG] M.Sc. TechnoPhysics (/mhb/FB-PHY/cos-580/)
Livecycle-State	[NORM] Active

Courses

Lehrveranstaltungen im Umfang von mindestens 16 LP aus folgendem Lehrveranstaltungsangebot (je nach Angebot):

Type/SWS	Course Number	Choice in Module-Part	SL	PL	CP	Sem.
2V	**MV-WKK-86166-K-7** (/mhb/courses/MV-WKK-86166-K-7/)	WP	-	see comments	3.0	WiSe
2V	**MV-WKK-86156-K-4** (/mhb/courses/MV-WKK-86156-K-4/)	WP	-	see comments	3.0	WiSe
2V	**MV-WKK-86152-K-7** (/mhb/courses/MV-WKK-86152-K-7/)	WP	-	see comments	3.0	SuSe
2V	**MV-WKK-86153-K-4** (/mhb/courses/MV-WKK-86153-K-4/)	WP	-	see comments	3.0	WiSe
2V+1U	**MV-WKK-86154-K-7** (/mhb/courses/MV-WKK-86154-K-7/)	WP	-	see comments	3.0	SuSe
2V	**MV-WKK-86162-K-4** (/mhb/courses/MV-WKK-86162-K-4/)	WP	-	see comments	3.0	SuSe
2V	**MV-WKK-89163-K-4** (/mhb/courses/MV-WKK-89163-K-4/)	WP	-	see comments	3.0	WiSe
2V	**MV-WKK-86157-K-4** (/mhb/courses/MV-WKK-86157-K-4/)	WP	-	see comments	3.0	WiSe
2V	**MV-AWP-86167-K-4** (/mhb/courses/MV-AWP-86167-K-4/)	WP	-	see comments	3.0	WiSe
2V	**MV-AWP-86165-K-7** (/mhb/courses/MV-AWP-86165-K-7/)	WP	-	see comments	3.0	SuSe
2V	**MV-AWP-86171-K-4** (/mhb/courses/MV-AWP-86171-K-4/)	WP	-	see comments	3.0	WiSe
2V	**MV-WKK-86165-K-4** (/mhb/courses/MV-WKK-86165-K-4/)	WP	-	see comments	3.0	SuSe

- About **[MV-WKK-86166-K-7]**: Title: "Materials selection in Mechanical Engineering"; Presence-Time: 28 h; Self-Study: 62 h
- About **[MV-WKK-86156-K-4]**: Title: "Cyclic Deformation Behaviour I"; Presence-Time: 28 h; Self-Study: 62 h
- About **[MV-WKK-86152-K-7]**: Title: "Cyclic Deformation Behaviour II"; Presence-Time: 28 h; Self-Study: 62 h
- About **[MV-WKK-86153-K-4]**: Title: "Construction Materials I"; Presence-Time: 28 h; Self-Study: 62 h
- About **[MV-WKK-86154-K-7]**: Title: "Construction Materials II"; Presence-Time: 42 h; Self-Study: 48 h
- About **[MV-WKK-86162-K-4]**: Title: "Fusion welding and pressure welding technology I"; Presence-Time: 28 h; Self-Study: 62 h
- About **[MV-WKK-89163-K-4]**: Title: "Fusion welding and pressure welding technology II"; Presence-Time: 28 h; Self-Study: 62 h
- About **[MV-WKK-86157-K-4]**: Title: "High Temperature Materials"; Presence-Time: 28 h; Self-Study: 62 h
- About **[MV-AWP-86167-K-4]**: Title: "Materials Testing"; Presence-Time: 28 h; Self-Study: 62 h
- About **[MV-AWP-86165-K-7]**: Title: "Failure Analysis"; Presence-Time: 28 h; Self-Study: 62 h
- About **[MV-AWP-86171-K-4]**: Title: "Plasticity of Metallic Materials"; Presence-Time: 28 h; Self-Study: 62 h
- About **[MV-WKK-86165-K-4]**: Title: "Metal-based lightweight materials"; Presence-Time: 28 h; Self-Study: 62 h

Some of the courses take place at irregular intervals. A current overview of the courses offered can be found in the campus management system of the TU Kaiserslautern (https://www.kis.uni-kl.de (https://www.kis.uni-kl.de)).

Note on credits, test performances and examinations:

The lecturers determine the credits, test performances and examinations. The examination modalities follow the practices of the respective oganizing department or institution.

Students are strongly advised to inform themselves at the respective lecturers at the beginning of the course.

Evaluation of grades

All partial module examinations have to be passed. The module grade is the arithmetic mean of all partial examination grades.

Contents

From [MV-WKK-86166-K-7] Materials selection in Mechanical Engineering (/mhb/courses/MV-WKK-86166-K-7/):

A reasonable selection of suitable materials is essential for the success of a product. The enormous number of materials available still increases constantly due to research and development of new materials coupled to an increasing performance of every single material. Therefore, the process of materials selection is dynamic and has to be adapted to the current situation to ensure the success of products.

The main objectives of the lecture are:

- General aspects and motivation for materials selection
- An overview about the most important structural and functional materials
- Selected methods for materials selection
- Property maps and material indices
- Conflicts between requirements and material properties
- Influence of geometry and shape factors
- Hybrid materials and composites
- Industrial design and manufacturing
- Influence of operating temperatures
- Results of incorrect materials selection
- Selected examples for materials selection in practice

From [MV-WKK-86156-K-4] Cyclic Deformation Behaviour I (/mhb/courses/MV-WKK-86156-K-4/):

- Fatigue lifetime
- Cyclic deformation behavior
- Influence of the microstructure on the fatigue strength
- Micro-crack initaion
- Crack propagation and fracture mechanics
- Influencing factors on fatigue strength of metallic materials
- Modern testing and measuring methods

From [MV-WKK-86152-K-7] Cyclic Deformation Behaviour II (/mhb/courses/MV-WKK-86152-K-7/):

In addition to the classical fatigue processes under constant amplitude loadings at constant temperature treated in the lecture “Fatigue of Metallic Materials I”, numerous technical components are subject to more complex cyclic stress states. These are (i) thermomechanical fatigue due to temporally and spatially variable temperatures, e.g., caused by start-stop processes of facilities operated at high temperatures, (ii) ultra-high cycle fatigue with load cycles beyond the typical fatigue limits at 106 to 107 cycles and (iii) fatigue with load amplitudes and frequencies that change over the service life. In-depth knowledge of the material behavior under such complex loads, and of suitable modeling approaches, is essential for the safe design of a large number of safety-relevant components in mechanical and process engineering.

The lecture first gives an overview of the technical background and experimental investigation of these complex variants of fatigue loading. Then the material behavior in case of thermomechanical fatigue, ultra-high cycle fatigue and variable amplitudes is presented and discussed. The focus here is on understanding the interactions of complex fatigue loadings, microstructure, deformation and damage mechanisms and service life. On this basis, models for service life assessment for the considered types of fatigue loading are presented and evaluated, using exemplary test results.

From [MV-WKK-86153-K-4] Construction Materials I (/mhb/courses/MV-WKK-86153-K-4/):

- Selection criteria for construction materials
- Classification of steels
- Thermodynamic aspects of phase transformation
- Transformation of steels from the austenite area
- Time-temperature transformation diagrams
- Selected heat treatments (thermal, thermo-mechanical, chemical-thermal processes)
- Additive manufacturing

From [MV-WKK-86154-K-7] Construction Materials II (/mhb/courses/MV-WKK-86154-K-7/):

- TRansformation Induced Plasticity / TWining Induced Plasticity (TRIP/TWIP) steels
- Aluminum and its alloys

- Magnesium and its alloys
- Titanium and its alloys
- Nickel and its alloys
- Ceramic materials

From [MV-WKK-86162-K-4] Fusion welding and pressure welding technology I (/mhb/courses/MV-WKK-86162-K-4/):

- Criteria for the weldability of components
- Microstructure evolution in fusion welding process
- Technical applications of welded joints on various steels, light metals as well as other alloys
- Functional principals of important fusion welding processes, such as:
  - Arc welding (MIG, MAG, TIG)
  - Laser beam welding
  - Electron-beam welding

From [MV-WKK-89163-K-4] Fusion welding and pressure welding technology II (/mhb/courses/MV-WKK-89163-K-4/):

- Functional principals of important pressure welding processes, such as:
  - Ultrasonic welding
  - Friction welding
  - Friction stir welding
  - Resistance welding
  - Diffusion welding
- Microstructure evolution in pressure welding process
- Technical applications of welded joints on various metals as well as hybrid joining
- Novel research in the field of ultrasonic welding
- Destructive and non-destructive test methods for fusion and pressure welded joints

From [MV-WKK-86157-K-4] High Temperature Materials (/mhb/courses/MV-WKK-86157-K-4/):

High-temperature components in gas turbines for power plants and aircraft engines as well as in modern steam turbine systems are subject to high mechanical stresses at temperatures that can reach up to 90% of the melting point of the materials used. In-depth knowledge of the loadings that occur and the properties of typical high-temperature materials, i.e., nickel and cobalt-based alloys, high-temperature steels and ceramic thermal barrier coating systems, is therefore essential for the safe design of such components.

The lecture first gives an overview of the requirements for materials in modern high-temperature components and discusses the essential loading types (creep loading, high-temperature fatigue, high-temperature corrosion, thermomechanical fatigue). The most important high-temperature materials, i.e., heat resistant steels, Ni-base alloys, Co-base alloys and thermal barrier coating systems, are then presented, with a focus on a sound understanding of the relationships between material composition, microstructure and application relevant properties.

From [MV-AWP-86167-K-4] Materials Testing (/mhb/courses/MV-AWP-86167-K-4/):

- Mechanical materials testing
- Light microscopy
- Electron microscopy
- Structural analysis with X-rays
- Ultrasonic testing
- in situ measurement techniques

From [MV-AWP-86165-K-7] Failure Analysis (/mhb/courses/MV-AWP-86165-K-7/):

- Types of stress on materials - mechanical, thermal, chemical, tribological stress and combinations thereof
- Representation of the different micro- and macroscopic fracture characteristics in connection with the previous stress - damage patterns
- Procedure and execution of a systematic damage analysis (VDI Guideline 3822)
- Materialographic examination and testing methods
- Illustrative examples of known cases of damage

From [MV-AWP-86171-K-4] Plasticity of Metallic Materials (/mhb/courses/MV-AWP-86171-K-4/):

- Macroscopic view of plastic deformation
- Microscopic view of plastic deformation
- Dislocation theory
- Microscopic influences on plastic deformation

From [MV-WKK-86165-K-4] Metal-based lightweight materials (/mhb/courses/MV-WKK-86165-K-4/):

The lecture „Metallic Lightweight Materials" addresses the important alloys used for lightweight constructions, whereby the alloys based on titanium, aluminum and magnesium are focused. On basis of titanium and aluminum alloys, the potential as well as the limits of additive manufacturing for lightweight design will be discussed. Additionally, advanced lightweight conceptions, i.e., metallic foams, particle reinforced metal matrix and metal fiber reinforced composites will be presented. Moreover, selected and current industrial examples of lightweight constructions will be shown. An overview of the content of the lecture is given in the following:

- Significance of lightweight metals and lightweight constructions as well as their selection requirements
- Aluminum and aluminum alloys
- Titanium and titanium alloys
- Magnesium and magnesium alloys
- Potential and limits of additive manufacturing for lightweight design
- Lightweight design based on steel as material
- Metallic foams
- Metal fiber laminates

Competencies / intended learning achievements

Die erfolgreiche Absolvierung dieses Moduls führt zu folgenden Kenntnissen & Fertigkeiten (als Lernergebnissen) und Kompetenzen:

- die Werkstoffkunde und ihre vielfältigen Aspekte soweit zu verstehen, dass die gelehrten Methoden und Denkweisen auf Fragestellungen aus diesem Bereich angewendet werden können (Fachkompetenz).
- ein strukturiertes Fachwissen (Verfügungswissen) zu den Teilgebieten und Themen der Werkstoffkunde, die inhaltlicher Gegenstand der oben genannten Lehrveranstaltungen dieses Vertiefungsmoduls sind (Fachkompetenz)
- das Verständnis des Zusammenwirkens von theoretischen Betrachtungen und praktischer Handhabung von Messsystemen und -methoden
- ein Überblickswissen (Orientierungswissen) zu den aktuellen, grundlegenden Fragestellungen der Werkstoffkunde und Werkstofftechnik (Fachkompetenz)
- das Verständnis der Abweichungen von theoretischen Vorhersagen und experimentellen Ergebnissen (Fachkompetenz).
- die Vertrautheit mit den Erkenntnismethoden, speziell bezogen auf die Werkstoffkunde und Erfahrungen in der exemplarischen Anwendung dieser Methoden in der Ingenieurwissenschaft (Methodenkompetenz)
- die Vertrautheit mit den Arbeitsmethoden, speziell bezogen auf die Werkstoffkunde und Erfahrungen in der exemplarischen Anwendung dieser Methoden in der Ingenieurwissenschaft (Methodenkompetenz)
- die Beherrschung der wichtigsten Arbeitsstrategien und Denkformen und damit auch die Vertrautheit mit den Strategien, Probleme der Werkstoffkunde selbstständig zu identifizieren, zu strukturieren und systematisch zu lösen (Methoden- & Selbstkompetenz)

Literature

From [MV-WKK-86166-K-7] Materials selection in Mechanical Engineering (/mhb/courses/MV-WKK-86166-K-7/):

- M. F. Ashby: Materials Selection in Materials Design. 4rd edition, Elsevier Verlag, 2011
- M.F. Ashby, A. Wanner (Hrsg.) C. Fleck (Hrsg.): Materials Selection in Mechanical Design: Das Original mit Übersetzungshilfen. Easy-Reading-Ausgabe, 3. Aufl., Spektrum Akademischer Verlag, 2006
- M. Reuter: Methodik der Werkstoffauswahl – Der systematische Weg zum richtigen Material. Hanser Verlag, 2007
- J. Grosch: Werkstoffauswahl im Maschinenbau. Band 199, Kontakt und Studium: Werkstofftechnik, Expert Verlag, 1986
- K.G. Budinsky and M.K. Budinsky : Engineering Materials, Properties and Selection. 6th edition, Prentice Hall, London, UK, 1999
- M. Kutz: Handbook of Materials Selection. John Wiley & Sons, New York, USA, 2002

From [MV-WKK-86156-K-4] Cyclic Deformation Behaviour I (/mhb/courses/MV-WKK-86156-K-4/):

- D. Radaj: Ermüdungsfestigkeit, Springer-Verlag
- S. Suresh: Fatigue of Materials, Cambridge University Press
- H.-J. Christ: Wechselverformung von Metallen, Springer-Verlag

From [MV-WKK-86152-K-7] Cyclic Deformation Behaviour II (/mhb/courses/MV-WKK-86152-K-7/):

Will be announced during the course.

From [MV-WKK-86153-K-4] Construction Materials I (/mhb/courses/MV-WKK-86153-K-4/):

- Verein Deutscher Eisenhüttenleute: Werkstoffkunde Stahl Band 1 u. 2, Springer Verlag und Verlag Stahleisen GmbH;
- W. Schatt: Werkstoffe des Maschinen-, Anlagen- und Apparatebaus, Deutscher Verlag für Grundstoffindustrie;
- W. Bergmann: Werkstofftechnik Teil 1: Grund- lagen, Teil 2 Anwendungen, Carl Hanser Verlag.

From [MV-WKK-86154-K-7] Construction Materials II (/mhb/courses/MV-WKK-86154-K-7/):

- Verein Deutscher Eisenhüttenleute: Werkstoffkunde Stahl Band 1 u. 2, Springer Verlag und Verlag Stahleisen GmbH;
- W. Schatt: Werkstoffe des Maschinen-, Anlagen- und Apparatebaus, Deutscher Verlag für Grundstoffindustrie;
- W. Bergmann: Werkstofftechnik Teil 1: Grundlagen, Teil 2 Anwendungen, Carl Hanser Verlag.

From [MV-WKK-86162-K-4] Fusion welding and pressure welding technology I (/mhb/courses/MV-WKK-86162-K-4/):

- G. Schulze: Die Metallurgie des Schweißens, Springer Verlag
- J. Ruge: Handbuch der Schweißtechnik, Springer Verlag
- H. Fahrenwaldt: Schweißtechnik, Vieweg Verlag

From [MV-WKK-89163-K-4] Fusion welding and pressure welding technology II (/mhb/courses/MV-WKK-89163-K-4/):

- J. Ruge: Handbuch der Schweißtechnik, Springer Verlag
- H. Fahrenwaldt: Schweißtechnik, Vieweg Verlag
- U. Dilthey: Schweißtechnische Fertigungsverfahren 1 und 2, Springer Verlag

From [MV-WKK-86157-K-4] High Temperature Materials (/mhb/courses/MV-WKK-86157-K-4/):

- Bürgel, Maier, Niendorf: Handbuch Hochtemperatur-Werkstofftechnik, Vieweg, Braunschweig

From [MV-AWP-86167-K-4] Materials Testing (/mhb/courses/MV-AWP-86167-K-4/):

Macherauch, Zoch: Praktikum in Werkstoffkunde, 11. Auflage, Vieweg Teubner, 2011

From [MV-AWP-86165-K-7] Failure Analysis (/mhb/courses/MV-AWP-86165-K-7/):

- Grosch, J.: Schadenskunde im Maschinenbau, 4. Auflage 2003, Expert-Verlag
- Lange, G.: Systematische Beurteilung technischer Schadensfälle, 5. Auflage 2003, Wiley-VCH
- Hertzberg, W.: Deformation and fracture mechanics of engineering materials, 1995, Wiley
- Dowling, N.E.: Mechanical behaviour of materials: Engineering methods for deformation, fracture and fatigue, 2. Auflage 1998, Prentice Hill
- Oettel, H.; Schumann, H.: Metallographie, 14. Auflage 2004, Wiley

From [MV-AWP-86171-K-4] Plasticity of Metallic Materials (/mhb/courses/MV-AWP-86171-K-4/):

- W. Dahl, R. Kopp, O. Pawelski (Hrsg.): Umformtechnik, Plastomechanik und Werkstoffkunde. Verlag Stahleisen, Düsseldorf und Springer-Verlag, Berlin
- P. Haasen: Physikalische Metallkunde. Springer-Verlag, Berlin
- R. Hertzberg: Deformation and Fracture of Engineering Materials. J. Wiley, New York
- D. Hull: Introduction to Dislocations. Pergamon Press, Oxford
- H. Mughrabi (Ed.): Plastic Deformation amd Fracture of Materials. In Materials Science and Technology, Vol. 6, Verlag Chemie VCH, Weinheim
- W. Schatt (Hrsg.): Einführung in die Werkstoffwissenschaft. Deutscher Verlag für Grundstoffindustrie, Leipzig
- J. Weertman, J.R. Weertmann: Elementary Dislocation Theory. Oxford University Press, Oxford

From [MV-WKK-86165-K-4] Metal-based lightweight materials (/mhb/courses/MV-WKK-86165-K-4/):

- H.P. Degischer (Hrsg.), S. Lüftl (Hrsg.): Leichtbau - Prinzipien, Werkstoffauswahl und Fertigungsvarianten; Wiley-VCH Verlag, Weinheim, 2009
- B. Klein: Leichtbau-Konstruktion - Berechnungsgrundlagen und Gestaltung; 10. Auflage, Springer Vieweg, Wiesbaden,

2013.
- H.E. Friedrich (Hrsg.): Leichtbau in der Fahrzeugtechnik; Springer Vieweg, Wiesbaden, 2013.
- F. Henning (Hrsg.), E. Moeller (Hrsg.): Handbuch Leichtbau - Methoden, Werkstoffe, Fertigung; Carl Hanser Verlag, München, 2011.
- E. Moeller, Handbuch Konstruktionswerkstoffe: Auswahl, Eigenschaften, Anwendung; 1. Auflage; Carl Hanser Verlag, 2007
- F. Ostermann: Anwendungstechnologie Aluminium; 3. Auflage, Springer Vieweg, Wiesbaden, 2014
- M. Peters (Hrsg.), C. Leyens (Hrsg.): Titan und Titanlegierungen; 3. Auflage, Wiley-VCH Verlag, Weinheim, 2002
- H.E. Friedrich, B.L. Mordike: Magnesium Technology - Metallurgy, Design Data and Applications; Springer Berlin Heidelberg, 2006

Materials

depending on choice, see respective course description

Registration

depending on choice, see respective course description

Requirements for attendance (informal)

depending on choice, see respective course description

Requirements for attendance (formal)

None

References to Module / Module Number [PHY-SP-6-M-7]

Module-Pool	Name
[PHY-SP-MV-MPOOL-7 (/mhb/modulepools/PHY-SP-MV-MPOOL-7/)]	Schwerpunktmodule aus dem Bereich Maschinenbau und Verfahrenstechnik: