课程详述

COURSE SPECIFICATION

以下课程信息可能根据实际授课需要或在课程检讨之后产生变动。如对课程有任何疑问，请联系授课教师。

The course information as follows may be subject to change, either during the session because of unforeseen circumstances, or following review of the course at the end of the session. Queries about the course should be directed to the course instructor.

1.	**课程名称 Course Title**	**工程材料—科学、工艺与设计** **Engineering Materials - Science, Processing and Design**
2.	**授课院系** **Originating Department**	机械与能源工程系 Department of Mechanical and Energy Engineering
3.	**课程编号** **Course Code**	ME261
4.	**课程学分 Credit Value**	3
5.	**课程类别** **Course Type**	专业基础课 Major Foundational Courses
6.	**授课学期** **Semester**	春季 Spring / 秋季 Fall
7.	**授课语言** **Teaching Language**	中英双语 English & Chinese
8.	**授课教师、所属学系、联系方式（如属团队授课，请列明其他授课教师）** **Instructor(s), Affiliation& Contact** **（For team teaching, please list all instructors）**	春节学期： 徐少林/助理教授/机械与能源工程系 Shaolin Xu / Assistant professor / Department of Mechanical and Energy Engineering Email: xusl@sustech.edu.cn 秋季学期： 王帅/助理教授/机械与能源工程系 Shuai wang/ Assistant professor / Department of Mechanical and Energy Engineering Email: wangs@sustech.edu.cn
9.	**实验员/助教、所属学系、联系方式** **Tutor/TA(s), Contact**	待公布 To be announced
10.	**选课人数限额(可不填)** **Maximum Enrolment（Optional）**	

11. 授课方式 Delivery Method	讲授 Lectures	习题/辅导/讨论 Tutorials	实验/实习 Lab/Practical	其它(请具体注明) Other（Please specify）	总学时 Total
学时数 Credit Hours	48				48

12. 先修课程、其它学习要求 Pre-requisites or Other Academic Requirements	CH101B General Chemistry B 化学原理 B PHY105B General Physics II B 大学物理 B(下)
13. 后续课程、其它学习规划 Courses for which this course is a pre-requisite	
14. 其它要求修读本课程的学系 Cross-listing Dept.	

教学大纲及教学日历 SYLLABUS

15. 教学目标 Course Objectives

随着科学技术的进步和新工程领域的快速发展，高校工程科学相关专业的教学和研究正在发生深刻的变化，机械工程、机器人、航空航天工程、生物医学工程等专业学生无论升学还是就业都会经常接触到工程材料的实际应用和相关理论。今天我们培养的工程师必须掌握各类工程材料的结构、性能、设计、加工、应用等方面的基础知识，才能够在前沿复杂的工程实践中对材料有充分的了解，并且根据使用需求对材料的工艺和设计做出正确的选择。本课程主要面向工程科学相关专业的大二学生，目的是使学生掌握晶体学、缺陷、扩散、相变等工程材料应用的基础科学原理，理解调控材料的力学、电学、热学和磁力性能的工艺基础，熟悉不同工程材料的设计准则和选择方法，为后续课程和将来的研究工作打下基础。

With the advance of science and technology and the rapid development of new engineering fields, the teaching and research of engineering science related majors in universities are undergoing profound changes. Students from majors of mechanical engineering, robotics, aerospace engineering, biomedical engineering are often exposed to the practical application of engineering materials and related theories. Nowadays, in order to fully understand the materials' properties in the frontier complex engineering practices, and to make the right choice for the processing and design of the material according to the needs of use, a well-educated engineer must master the basic knowledge of the structure, performance, design, processing, and application of various engineering materials. This course is designed for sophomores majoring in engineering science. The purpose is to enable students to master the basic scientific principles for applications of engineering materials, such as crystallography, defects, diffusion, phase transformation, and to understand the mechanics, electrical, thermal and magnetic properties of materials, and to be familiar with the design criteria and selection methods of different engineering materials, laying the foundation for subsequent courses and future research work.

16. 预达学习成果 Learning Outcomes

本课程以工程材料学的基础科学问题为中心，从培养工程师的角度出发，从如下四个部分讲解：①基础知识；②材料制备方法；③各种材料简述；④材料的力学、物理和化学性能，预期通过学习过程中的思维锻炼，能够为未来从事工程科学方面的研究积累选材设计方面的知识。通过本课程的学习，学生应当可以：

1. 熟悉原子键合种类；熟悉常见材料的晶体结构；会使用米勒指数表示晶体学方向；能够描述常见晶系的特征；

2. 能描述材料内部缺陷种类；熟悉常见缺陷分析技术；了解缺陷与材料性能设计的关系；

3. 熟悉扩散原理；能描述第一、第二 Fick 定律；了解扩散的原子模型；会使用扩散方程计算基本应用问题；熟悉影响扩散的主要因素；了解控制扩散的工艺技术；

4. 熟悉焓、熵、吉布斯自由能的基本概念；了解相变的热力学原理；会使用相律；会使用相图的杠杆原理计算相的成分比例；能描述凝固过程均匀和非均匀形核的热力学过程；熟悉凝固工艺选择的原理；

5. 熟悉常用弹性模量的物理意义及其分类；了解胡克定律的张量形式；熟悉各向异性和各向同性的物理意义；熟悉拉伸变形的不同阶段；了解材料的疲劳和蠕变及其在材料服役中的重要性；

6. 熟悉材料强化工艺的设计方法；了解晶界工程学；熟悉材料的失效原理；了解失效准则；了解材料的安全设计方法；

7. 熟悉常见的工程合金种类及合金化设计原理；了解超强钢工艺方法；熟悉典型工件的选材准则和优化方案；

8. 熟悉常见的聚合物加工方法、种类、性能和工艺设计原理；熟悉常见陶瓷材料的光、电、热、力学性能和工艺设计原理；熟悉常见的复合材料的设计原理及其应用场景；

9. 认识工程材料使用过程中对环境的影响；熟悉环境友好型材料的设计原则；了解工程材料在解决能源问题中的关键作用；

This course focuses on the basic scientific issues of engineering materials science. From the perspective of training engineers, the following four parts are explained: 1. basic knowledge; 2. material processing methods; 3. brief introductions to various materials; 4. materials mechanics, physics and chemistry performance. We expect students to gain knowledge in the selection and design of materials for future research in engineering science through the exercise of thinking in the learning process. Through this course, students are supposed to:

1. Be familiar with the atomic bonding species; be familiar with the crystal structure of common materials; can use the Miller index to indicate the crystallographic direction; can describe the characteristics of common crystal systems.

2. Can describe the types of internal defects of materials; be familiar with common defect analysis techniques; understand the relationship between defects and material performance design.

3. Be familiar with the diffusion principle; can describe the first and second Fick laws; understand the atomic model of diffusion; use the diffusion equation to calculate basic application problems; be familiar with the main factors affecting diffusion; understand the processing technology of controlling diffusion.

4. Be familiar with the basic concepts of enthalpy, entropy, and Gibbs free energy; understand the thermodynamic principles of phase transition; can use phase law; can use the leverage principle of phase diagram to calculate the composition ratio of phases; can describe the thermodynamics of uniform and nonuniform nucleation in solidification process; be familiar with the principle of solidification process selection;

5. Be familiar with the physical meaning and classification of common elastic modulus; understand the tensor form of Hooke's law; be familiar with the physical meaning of anisotropy and isotropic; be familiar with the different stages of tensile deformation; understand the fatigue and creep of materials and their importance in materials serving.

6. Be familiar with the design method of material strengthening processes; understand the grain boundary engineering; be familiar with the failure principle of materials; understand the failure criterion; understand the safety design method of materials.

7. Be familiar with common engineering alloy types and alloying design principles; understand super-strong steel processing methods; be familiar with the selection and optimization criteria of typical workpieces;

8. Be familiar with common polymer processing methods, types, performance and design principles; be familiar with the light, electricity, heat, mechanical properties and processing principles of common ceramic materials; be familiar with the common composite material design principles and application scenarios;

9. Recognize the impact on the environment during the use of engineering materials; be familiar with the design principles of environmentally friendly materials; understand the key role of engineering materials in solving energy problems.

17. 课程内容及教学日历 （如授课语言以英文为主，则课程内容介绍可以用英文；如团队教学或模块教学，教学日历须注明主讲人）
Course Contents (in Parts/Chapters/Sections/Weeks. Please notify name of instructor for course section(s), if this is a team teaching or module course.)

1. 工程材料引论（4 学时）：对课程安排进行简要介绍、然后介绍工程材料的定义、种类、最新发展、工程材料的设计及选择原则
Introduction to engineering materials (4 credit hours): course introduction, definition/types/recent advances of engineering materials, design and selection principles of engineering materials

2. 原子结构与键合（4 学时）：主要介绍原子结构、金属键、共价键、离子键、高分子链
Atomic structure and bonding (4 credit hours): atomic structure, metal bond, covalent bond, ionic bond, polymer chain

3. 晶体结构与非晶态结构（6 学时）：主要介绍空间点阵、晶胞、晶系、主要晶体结构、晶体结构分析、非晶态材料
Crystal and amorphous structures in materials (6 credit hours): the space lattice, unit cells, crystal systems, principal crystal structures, crystal structure analysis, amorphous materials

4. 晶体缺陷（4 学时）：主要介绍点缺陷、线缺陷（位错）、面缺陷、体缺陷，并简要介绍微观结构和缺陷的分析检测技术
Crystalline imperfections (4 credit hours): point defects, line defects (dislocations), planar defects, volume defects, experimental techniques for identification of microstructure and defects

5. 扩散原理与应用（4 学时）：主要介绍固体中的速率过程、原子扩散、扩散的控制工艺，并简要介绍扩散过程在工业中的应用
Diffusion principle and application (4 credit hours): rate processes in solids, atomic diffusion in solids, diffusion control process, industrial applications of diffusion processes

6. 相变与凝固（4 学时）：主要介绍热力学基础、吉布斯相律、二元系相图、三元系相图、金属凝固、单晶体的凝固、金属固溶体
Phase transformation and solidification (4 credit hours): Thermodynamic basics; Gibbs phase rule, binary phase diagram, ternary phase diagram, solidification of metals, solidification of single crystals, metallic solid solutions

7. 工程材料力学性能（4 学时）：主要介绍弹性力学基础、单晶体/多晶体的弹性形变、塑性形变、疲劳和蠕变
Mechanical properties of engineering materials (4 credit hours): foundation of elastic mechanics, elastic and plastic deformation of metal single crystals and polycrystals, fatigue and creep

8. 力学性能极限设计（4 学时）：主要介绍强化工艺（固溶强化、应变硬化、晶界强化）、失效行为与失效准则，并对服役强度、寿命预测与提升工艺简要介绍
Mechanical performance limit design (4 credit hours): strengthening process (solid solution strengthening, strain hardening, grain boundary strengthening), failure behavior and failure criterion, service intensity, life prediction and the enhance process

9. 工程合金（4 学时）：主要介绍铁碳系统、普通碳素钢的热处理，并对低合金钢、铝合金的性能进行简要介绍
Engineering alloys (4 credit hours): the iron-carbon system, heat treatment of plain-carbon steels, low-alloy steels, aluminium alloys

10. 典型工件的选材及工艺路线设计（2 学时）：主要介绍齿轮选材、轴类零件选材、弹簧选材、刃具选材
Material selection and process route design of typical workpieces (4 credit hours): gear material selection, shaft parts material selection, spring material selection, cutting tool material selection

11. 聚合物材料（2 学时）：主要介绍聚合反应、聚合方法，并对热塑性塑料、热固性塑料的性能进行简要介绍
Polymeric materials (2 credit hours): polymerization reactions, polymerization methods, thermoplastics, thermoset plastics

12. 陶瓷材料（2 学时）：简要介绍简单陶瓷晶体结构、硅酸盐结构、陶瓷制备过程、热力性能
Ceramics (2 credit hours): simple ceramic crystal structures, silicate structures, processing of ceramics, mechanical and thermal properties of ceramics.

13. 复合材料（2 学时）：简要介绍纤维增强塑料类复合材料、金属基陶瓷类复合材料
Composite materials (2 credit hours): fiber reinforced plastic composite materials, metal-matrix and ceramics-matrix

composites

14.工程材料与环境能源：挑战和希望 （2 学时）：简要介绍材料的消耗、材料的回收利用、生产过程中的能量消耗及污染、能源问题与工程材料、能源友好型材料选择
Engineering materials versus environment and energy: challenge and prospect (2 credit hours): consumption of materials, recycle of materials, energy consumption and pollution, energy questions and engineering materials, selection of eco-friendly materials

18. 教材及其它参考资料 Textbook and Supplementary Readings

教材：

(1) Foundations of Materials Science and Engineering, William F. Smith, Javad Hashemi, 6th edition, 2019, New York, NY: McGraw-Hill Education.

参考教材：

(2) Fundamentals of Materials Science and Engineering, William D. Callister, Jr., David G. Rethwisch, 5th Edition, 2015, Wiley.

(3) Engineering Materials 1 – An Introduction to Properties, Applications, and Design, Michael F. Ashby, David R. H. Jones, 4th edition, 2012, Butterworth-Heinemann

(4) Engineering Materials 2 - An Introduction to Microstructures and Processing, Michael F. Ashby, David R. H. Jones, 4th edition, 2012, Butterworth-Heinemann

(5) 工程材料, 朱张校, 姚可夫, 第 5 版, 2011, 清华大学出版社

(6) 材料科学基础, 余永宁, 第 2 版, 2012, 高等教育出版社

课程评估 ASSESSMENT

19.

评估形式 Type of Assessment	评估时间 Time	占考试总成绩百分比 % of final score	违纪处罚 Penalty	备注 Notes
出勤 Attendance		10		
课堂表现 Class Performance		10		
小测验 Quiz				

课程项目 Projects				
平时作业 Assignments		30		
期中考试 Mid-Term Test				
期末考试 Final Exam		50		
期末报告 Final Presentation				
其它（可根据需要改写以上评估方式） Others (The above may be modified as necessary)				

20. 记分方式 GRADING SYSTEM

■ A. 十三级等级制 Letter Grading
☐ B. 二级记分制（通过/不通过） Pass/Fail Grading

课程审批 REVIEW AND APPROVAL

21. 本课程设置已经过以下责任人/委员会审议通过
This Course has been approved by the following person or committee of authority

机械与能源工程系教学委员会