课程大纲
COURSE SYLLABUS

1.	**课程代码/名称** **Course Code/Title**	**工程结构分析与性能** **Structural Analysis and properties of Engineering**
2.	**课程性质** **Compulsory/Elective**	专业选修课 Major Elective Courses
3.	**课程学分/学时** **Course Credit/Hours**	3/48
4.	**授课语言** **Teaching Language**	English
5.	**授课教师** **Instructor(s)**	逯文君，助理教授，机械与能源工程系， Email: luwj@sustc.edu.cn Wenjun Lu, Assistant Professor, Department of Mechanical and Energy Engineering, Email: luwj@sustech.edu.cn
6.	**是否面向本科生开放** **Open to undergraduates or not**	否 No
7.	**先修要求** **Pre-requisites**	（如面向本科生开放，请注明区分内容。 If the course is open to undergraduates, please indicate the difference.） 无

8. 教学目标
Course Objectives

（如面向本科生开放，请注明区分内容。 If the course is open to undergraduates, please indicate the difference.）

本课程主要是让学生了解并熟悉不同种类的常用工程合金与其应用-确保学生对工程合金设计做最优化的材料选择。同时提供给学生对工程材料结构以及相关力学性能的理解，本课程还介绍如何使用不同的热处理工艺和加工方法对材料的结构及性能的影响。另外，学生会了解到高级表征方法包括透射电子显微镜和三维原子探针在相关金属与合金的跨尺度结构分析中的应用。

This course familiarizes students with the various types of major engineering alloys and their applications - enabling them to make better decisions for materials selection for engineering designs. While providing an understanding of engineering structures and how they relate to the mechanical properties of engineering alloys, the course also offers information on how various heat treatments and processing techniques cause changes in the structure and property of alloys. In addition, students will find some advanced characterization methods including transmission electron microscopy (TEM) and 3D atom probe tomography (APT) relating to metals' and alloys' microstructures from macro- to atomic- scale.

9. 教学方法
Teaching Methods

（如面向本科生开放，请注明区分内容。 If the course is open to undergraduates, please indicate the difference.）
教室讲授，使用多媒体授课，进行案例解析，并设置课程报告环节，
Class room lecture, applying multimedia, case and reference study, class project (writing report + oral presentation)

10. 教学内容
Course Contents
（如面向本科生开放，请注明区分内容。 If the course is open to undergraduates, please indicate the

difference.）

本课程主要包括工程合金的四个方面：i) 结构、ii) 力学性能、iii) 典型应用以及 iv) 表征. 具体内容如下：

- 工程合金：结构-性能-加工-表现；材料选择
- 晶体学
- 结构与强化机制
- 力学性能
- 碳钢
- 不锈钢
- 铝合金
- 铜合金
- 钛合金
- 镍基和钴基合金
- 镁基和锌基合金
- 高熵合金
- 透射电子显微镜
- 三维原子探针

This course mainly focuses on four aspects of engineering alloys: i) microstructure, ii) mechanical properties, iii) typical applications and iv) characterization. Specific contents are as follows:

- Engineering alloys: Structure-Property-Processing-Performance; Materials Classifications
- Crystallography
- Microstructure and strengthening mechanisms
- Mechanical properties
- Carbon steels
- Stainless steels
- Aluminum alloys
- Copper alloys
- Titanium alloys
- Nickel and Cobalt alloys
- Magnesium and Zinc alloys
- High entropy alloys
- Transmission electron microscope
- 3D atom probe tomography

Section 1 (2 credits)	**Introduction of engineering alloys** Fundamentals, design, processing and applications **工程合金引论** 基础介绍、设计、加工以及应用
Section 2 (4 credits)	**Crystallography** Crystal state, the lattice and its properties, crystal structure, morphology, principles of symmetry and Bravais lattices **晶体学** 这一章节介绍晶体态、点阵以及性能、晶体结构、形貌、晶体对称理论和布拉格点阵
Section 3 (4 credits)	**Microstructure and strengthening mechanisms for engineering alloys** Defects, grain boundary and phase boundary, twinning, segregation and precipitation, strengthening mechanisms (work hardening, solid solution strengthening, grain size and dispersion strengthening) **工程合金结构与强化机制**

	这一章节介绍缺陷、晶界与相界、孪晶、偏聚与析出、合金强化机制（加工硬化、固溶强化、晶界强化和弥散强化）
Section 4 (6 credits)	**Fundamentals of mechanical properties** Introduction, the tensile test, bend testing, hardness testing, fracture toughness testing, time-dependent mechanical properties **力学性能基础** 这一章节介绍力学拉伸实验、弯曲实验、硬度实验、断裂力学、时间相关的力学性能
Section 5 (2 credits)	**Carbon steels** Fe-C phase diagram, slow cooling of carbon steels, isothermal transformation of an eutectoid carbon steels, phase transformation of (austenite to pearlite, austenite to martensite and austenite to bainite), continuous-cooling transformation, quench hardening, tempering **碳钢体系** 这一章节介绍铁-碳相图、碳钢慢冷机制、共晶碳钢的无扩散相变、相变(奥氏体到珠光体、奥氏体到马氏体和奥氏体到贝氏体)、连续降温相变，水淬及回火机制
Section 6 (2 credits)	**Stainless steels** Introduction, the Fe-Cr-Ni system, chromium carbides in austenitic steels, precipitation of niobium and titanium carbides, nitrides in austenitic steels, intermetallic precipitation in austenite, stainless steels (austenitic steels, duplex and ferritic steels) in practical applications **不锈钢体系** 这一章节介绍 Fe-Cr-Ni 经典不锈钢体系、碳化物（如碳化铬、碳化铌和碳化钛）在奥氏体不锈钢中的析出、氮化物以及金属间化合物的析出、不锈钢（如奥氏体、双相和铁素体）的实际应用
Section 7 (2 credits)	**Aluminium alloys** Introduction, temper designations, commercial pure Aluminium and Al alloys (e.g., Al-Mg, Al-Mn, Al-Cu, Al-Cu-Mg, Al-Mg-Si, Al-Zn-Mg, Al-Zn-Mg-Cu and Al-Li) **铝合金体系** 这一章节介绍介绍铝合金的回火设计、商业纯铝与工程铝合金的性能与应用
Section 8 (2 credits)	**Copper alloys** Introduction, the wrought of Copper, Copper alloys (Cu-Zn alloys, Cu-Sn alloys, Cu-Al alloys, Cu-Si alloys, Cu-Ni alloys, Cu-Ni-Zn alloys) **铜合金体系** 这一章节介绍铜的提取、铜合金的性能与应用

	Section 9 (2 credits)	**Titanium alloys** Introduction, pure Titanium, Ti alloys systems and phase diagrams, fracture toughness of Titanium alloys **钛合金体系** 这一章节阐述纯钛、钛合金的性能与应用
	Section 10 (2 credits)	**Nickel and Cobalt alloys** Introduction, pure Nickel and Cobalt, Alloys (Ni-Cu alloys, Ni-Cr alloys, Ni base superalloys, Ni-Fe base superalloys, Co base superalloys, single-crystal castings of Nickel-base alloy) **镍基与钴基合金体系** 这一章节分别介绍镍基与钴基合金的性能与应用
	Section 11 (2 credits)	**Magnesium and Zinc alloys** Introduction, properties and consumption of Magnesium, Mg alloys (e.g., Mg-Al alloys, Mg-Al-Zn alloys, Mg-Zn-Zr alloys), introduction to Zinc and its alloys **镁与锌合金体系** 这一章节分别介绍镁基与锌基合金的性能与应用
	Section 12 (6 credits)	**High entropy alloys** Overview of high entropy alloys, phase formation rules, fabrication routes, Mechanical properties, potential applications and prospects **高熵合金体系** 这一章节介绍高熵合金总论、相形成机理、制造方法、力学性能、潜在应用及展望
	Section 13 (8 credits)	**The basics of transmission electron microscope for engineering alloys** What materials should we study in the TEM? Why use electrons? Limitation of the TEM, different kinds of TEMs, sample preparation, diffraction from crystals, imaging planar defects, imaging strain fields, weak-beam dark-field imaging, high-resolution TEM, STEM, chemical measurements, In-situ microscopy **透射电子显微镜在工程合金中的基本应用** 为什么在研究工程和金时需要用到透射电子显微镜？为什么要用电子成像？电子显微镜的极限、电子显微镜的分类、样品制备、晶体衍射、缺陷的成像、应力场的成像、弱束暗场成像、高分辨成像、扫描电子显微镜、化学分析测量、原位电子显微镜技术
	Section 14 (4 credits)	**The basics of 3D atom probe tomography for engineering alloys** Introduction, sample preparation, analysis techniques for APT, APT for Engineering alloys' problems: e.g., phase composition, crystal defects, solute-atom clustering and short range order, precipitation reactions, long-range order, spinodal decomposition, interfaces, amorphous materials. **三维原子探针在工程合金中的基本应用** 这一章节主要展示三维原子探针在工程合金中的基本共工作原理、样品制备以及可以观测的工程问题，如相成分、晶体缺陷、元素团聚、短程

		有序、析出反应、长程有序、条幅分解、界面以及非晶材料

11.	**课程考核** **Course Assessment**
	①考核形式 Form of examination：Assessment ②分数构成 grading policy：a.出勤 Attendance 5%; b.课堂表现 Class performance 10%; c.课程项目 Projects 40%; d.期末报告 Final report/presentation 45%
12.	**教材及其它参考资料** **Textbook and Supplementary Readings**
	教材及参考材料： 1. Materials for Engineering, third edition, J. Martin 2. Structure and Properties of Engineering alloys, second edition, W.F. Smith 3. Transmission Electron Microscopy, A Textbook for Materials Science, third edition, D.B. Williams, C. B. Carter. 4. Atom probe Microscopy, first edition, B. Gault, M. P. Moody, J. M. Cairney, S. P. Ringer