# 课程大纲
# COURSE SYLLABUS

| | | |
|---|---|---|
| **1.** | **课程代码/名称**<br>**Course Code/Title** | **MSE5011 电化学能量储存与转换**<br>**Electrochemical Energy Storage and Conversion** |
| **2.** | **课程性质**<br>**Compulsory/Elective** | 专业选修课 |
| **3.** | **课程学分/学时**<br>**Course Credit/Hours** | 3/48 |
| **4.** | **授课语言**<br>**Teaching Language** | 英文/English |
| **5.** | **授课教师**<br>**Instructor(s)** | 李辉 讲席讲授 |
| **6.** | **是否面向本科生开放**<br>**Open to undergraduates or not** | 否 |
| **7.** | **先修要求**<br>**Pre-requisites** | 化学，物理化学<br>Chemistry， Physical Chemistry |

**8. 教学目标**
**Course Objectives**

本课程是介绍电化学及电化学工程的基本原理，以及它们在清洁能源和可持续能源领域的应用。本课程旨在让学生掌握电化学和电化学工程的基础理论知识，了解电化学理论如何应用于电化学能量储存与转换，明白常用的电化学能量装换和储存技术 （包括金属空气电池、液流电池、燃料电池、电解水制氢、二氧化碳电化学还原）的主要工作原理、性能、结构、应用及研究现状， 从而培养学生在新能源领域的创新能力。
This course will introduce the basic principles of electrochemistry and electrochemical engineering with focus on the electrochemical energy storage and conversion for applications in clean and sustainable energy. The course will equip the students with the knowledge of the working mechanisms、characteristics、applications and the state-of-the-art of some major electrochemical technologies（including flow batteries, metal-air batteries, fuel cells, water electrolysis, electrochemical reduction of CO2, etc），and help the students develop capabilities to conduct innovative research in electrochemical energy materials and to apply electrochemistry and electrochemical engineering for energy storage and conversion.

**9. 教学方法**
**Teaching Methods**

1.课程采用多媒体教学与板书结合的授课方式。课堂板书是为了使学生能充分理解课程内容。Multimedia will be the major teaching tool and board writing will be used as a supplementary tool to help students fully understand some difficult points.
2.教学中通过对案例分析的方法来阐述某些枯燥难懂的基本原理，使学生能够更深刻地掌握所学内容。Case study will be used to illustrate some of the difficult principles and topics, which will help students to grasp the knowledge in a more in-depth manner.
3.课程会邀请一到两个电化学或电化学工程专家，或者储能领域的专家来课堂讲座，使学生更深刻的了解该课程的应用及重要性。 One or two expert speakers in the areas of electrochemistry or electrochemical engineering or their applications in energy storage and conversion will be invited to give seminars on specific topics to help students understand how the related theory and principles are useful.
4.课程要求学生选定一个文献检索题目或者一个科研计划题目，通过文献检索来进行某个相关领域的文献检索与总结，或者对选定的科研课题做一个简单的研究设想。使学生能跟踪世界前沿的相关知识和技术。The course will require the student to select a literature review topic or a research planning topic to conduct and present the literature search or to propose a research topic. The goal is to help the student to understand the state-of-the-art of the area of his/her interest.
5.作业将采用灵活的方式， 约两周一次作业，其目的是强化学生对基础知识的掌握和理解。Homework will be required biweekly to ensure deeper understanding of the taught materials.
6.期末考试将采用在课堂上开卷的形式， 3小时， 将评价学生的理解能力而不是回想和记忆能力，考查学生利用已经掌握的基础知识和课堂记录灵活地利用电化学知识应用到新能源领域。Final exam will be using “open-note” style in classroom for 3 hours. Students will be evaluated on understanding rather than recalling and memorizing. Students will be examined on their abilities to apply electrochemistry and electrochemical

| | |
|---|---|
| | engineering to new areas of energy storage and conversion. |

**10. 教学内容**
**Course Contents**

| | |
|---|---|
| **Section 1** | 1.Fundamentals of electrochemistry ( week1-week3)<br>1.1Oxidation and reduction<br>1.2Electrochemical cells (systems)<br>1.3Thermodynamics and potential<br>1.4Kinetics and rates of reactions<br>1.5Electrocatalysis<br>1.6Electrode and electrolyte interfaces<br>1.7Nanomaterials in electrochemical applications<br>1.8Electrochemical methods<br>1.9Other terminologies |
| **Section 2** | 2.Electrochemical engineering through case-study of electrochemical reduction of CO2 (week 4-week 6)<br>2.1 Analysis of mechanism, thermodynamics and kinetics<br>2.2Selection of anode and cathode materials<br>2.3Porous electrode theory<br>2.4Design, structure and fabrication of electrochemical devices<br>2.5Experimental design of electrochemical processes<br>2.6Conceptual process design and economic projection |
| **Section 3** | 3.Electrochemical energy storage for renewable sources and grid balancing (week7 )<br>3.1Penetration of renewable energy into power networks<br>3.2The roles of energy storage<br>3.3Classification of energy storage technologies |
| **Section 4** | 4.Fundamentals and applications of batteries for energy storage(week8-week 9)<br>4.1Redox flow batteries<br>4.2Metal-air batteries<br>4.3Li batteries<br>4.4Sodium batteries |
| **Section 5** | 5.Fuel cells (week 10-week12)<br>5.1General introduction of various types of fuel cells<br>5.2Hydrogen PEM fuel cells |
| **Section 6** | 6.Hydrogen energy storage ( week13-week14)<br>6.1Hydrogen production from renewable energies- electrolyzer technologies<br>6.2Hydrogen conversion to electricity and thermal energy by fuel cells<br>6.3Hydrogen gas storage<br>6.4Power-to-gas<br>6.5PEM electrolyzer and PEM regenerative fuel cells<br>6.6Energy carriers made from hydrogen |
| **Section 7** | 7.Global carbon balance and carbon recycle ( week15)<br>7.1Energy and CO2<br>7.2CO2 and global heating<br>7.3CO2 recycling vs. electrochemical reduction of CO2 |
| **Section 8** | 8.Special talks by invited guests (week16) |
| **Section 9** | Final exam: (weeks 17&18 |

| | |
|---|---|
| **11.** | **课程考核**<br>**Course Assessment** |
| | Attendance: 10%:<br>Assignments: 20%<br>Mid-term: 20%<br>Final: 30%<br>Project and presentation: 20% |
| **12.** | **教材及其它参考资料**<br>**Textbook and Supplementary Readings** |
| | 1.Electrochemical Systems (Third Edition) by John Newman and Karen E. Thomas-Alyea. Published by: John Wiley & Sons, Inc. 2004.<br>2.Electrochemical Methods – Fundamentals and applications (Second Edition) by Allen J. Bard and Larry R. Faulkner. Published by: John Wiley & Sons, Inc. 2001.<br>3.Electrochemical Technologies for Energy Storage and Conversion by Ru-shi Liu, Lei Zhang, Xueliang Sun, Hansan Liu, Jiujun Zhang. Published by: WILEY-VCH, 2012.<br>4.《电化学原理 》（ 第三版），李荻，北京航空航天出版社， 2008。 |