Annexe A: New/Revised Course Content in OBTL+ Format

Course Overview

The sections shown on this interface are based on the templates UG OBTL+ or PG OBTL+
If you are revising/duplicating an existing course and do not see the pre-filled contents you expect in the subsequent sections e.g. Course Aims, Intended Learning Outcomes etc. please refer to Data Transformation Status for more information.

Expected Implementation in Academic Year	AY2024-25
Semester/Trimester/Others (specify approx. Start/End date)	Semester 1 Semester 2
Course Author * Faculty proposing/revising the course	XU Zhichuan, Jason (Prof)
Course Author Email	xuzc@ntu.edu.sg
Course Title	Materials for Hydrogen Fuel
Course Code	MS4682
Academic Units	1
Contact Hours	13
Research Experience Components	Not Applicable

Course Requisites (if applicable)

Pre-requisites	MS1013 Materials Chemistry I, MS1014 Materials Chemistry II , MS1017 Introduction to Materials Science, MS1016 Thermodynamics of Materials, MS3013 Electrochemical Corrosion
Co-requisites	
Pre-requisite to	
Mutually exclusive to	
Replacement course to	
Remarks (if any)	

Course Aims

The course aims to provide students with the knowledge of the hydrogen fuel, including the hydrogen production, storage, delivery, and use. It focuses on the fundamentals of materials science and engineering related to those processes. In addition to the fundamentals, this course will also bring the most recent development of materials in hydrogen fuel techniques to students. This cutting-edge course integrates fundamental principles of materials science and engineering, equipping students with the knowledge and skills vital for the evolving landscape of the energy and sustainability industry.

At the core of this course lies a deep dive into the multifaceted world of hydrogen fuel. Students will gain a robust understanding of the entire hydrogen fuel cycle, encompassing production methods, storage technologies, efficient delivery systems, and utilization applications. As we explore the fundamentals, we go beyond the basics to incorporate the latest advancements in materials crucial to the field. This course seamlessly integrates into the overarching program by offering a specialized focus on a burgeoning field. It enhances the program's curriculum by providing a unique blend of theoretical foundations and practical applications, aligning perfectly with the dynamic needs of the contemporary professional landscape. Furthermore, the expertise gained in this course positions students as valuable assets in industries spearheading the transition to sustainable energy sources. As professionals, they become catalysts for change, driving innovation, and influencing the adoption of hydrogen fuel technologies on a global scale.

Benefits for Students:

- Holistic Knowledge Base: By delving into the intricacies of materials science and engineering within the context of hydrogen fuel, students will cultivate a holistic knowledge base. This foundation extends beyond the theoretical, providing practical insights into the real-world applications of materials in hydrogen technologies.

- Cutting-Edge Insights: Our commitment to staying on the forefront of industry developments ensures that students receive the latest insights into the advancements of materials used in hydrogen fuel techniques. This exposure positions them as early adopters of innovative technologies, setting the stage for success in their future careers.

- Sustainability and Industry Transition: In an era where sustainability is paramount, this course serves as a catalyst for students to become key contributors to a greener future of Singapore. Understanding the role of materials in sustainable energy solutions enhances their capacity to drive positive change. As industries worldwide transition towards cleaner alternatives, students armed with this knowledge gain a competitive edge in the job market.

Course's Intended Learning Outcomes (ILOs)

Upon the successful completion of this course, you (student) would be able to:

ILO 1	Gain the insight view in green energy carrier hydrogen and sustainability
ILO 2	Understand the working mechanisms and principles of materials in traditional hydrogen production and purification processes
ILO 3	Master the fundamentals and working principles of materials in water electrolysis for hydrogen production and materials in fuel cells for hydrogen utilization
ILO 4	Understand the fundamentals and working principles of materials in hydrogen storage and delivery
ILO 5	Application of the gained knowledge in analysing and solving given problems, such as to evaluate and critique hydrogen manufacturing methods, to design and optimize materials for hydrogen transport and storage, to identify and solve technical limitations preventing hydrogen economy, etc.

Course Content

No	Topic	Hours
1	Introduction to hydrogen fuel	1
2	Hydrogen production and purification	3
3	Materials for water (photo)electrolysis	3
4	Hydrogen storage and transportation	3
5	Materials in hydrogen fuel cells	3
	Total	13

Reading and References (if applicable)

1. Sørensen, Bent & Spazzafumo, Giuseppe. "Hydrogen and Fuel Cells: Emerging Technologies and Applications." Publisher: Academic Press. Year: 2018.
2. Press, Roman J & Santhanam, K. S. V. "Introduction to Hydrogen Technology." Publisher: CRC Press. Year: 2018.
3. Vetrivel, Ramalingam. "Hydrogen Fuel: Production, Transport, and Storage." Publisher: CRC Press. Year: 2017.
4. Ball, Michael, Veziroğlu, T. N. "Hydrogen Energy: Challenges and Prospects." Publisher: Taylor & Francis. Year: 2007.
   (This is the latest version of this book)
5. The Hydrogen Revolution: A Blueprint for the Future of Clean Energy, Marco Alverà, Hachette Book Group, Nov 2021
6. Hydrogen Economy, The: Fundamentals, Technology, Economics, Duncan Seddon, World Scientific, May 2022
7. Hydrogen Production and Energy Transition, Marcel H. Voorde, De Gruyter, Sep 2021

Planned Schedule

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
1	Introduction to hydrogen fuel, hydrogen production	1, 2		In-person	Lecture
2	Hydrogen production and purification	2		In-person	Lecture
3	Materials for water (photo)electrolysis	3		In-person	Lecture
4	Materials for water electrolysis, Hydrogen storage and transportation	3,4		In-person	Lecture
5	Hydrogen storage and transportation	4		In-person	Lecture
6	Continuous Assessment (CA) 1			In-person	Continuous Assessment (CA)
7	Materials in hydrogen fuel cells	5		In-person	Lecture
8	Continuous Assessment (CA) 2			In-person	Continuous Assessment (CA)

Learning and Teaching Approach

Approach	How does this approach support you in achieving the learning outcomes?
Lecture-based classes (LBC)	The lectures are meticulously structured and delivered, allowing students to concentrate on specific key concepts, principles, and ideas in a systematic manner. The lectures integrate current research content and case studies, enhancing the coursework's relevance and sparking the curiosity of students.
Context-based learning (CBL)	Regular presentations on the practical applications of materials in hydrogen fuel techniques, coupled with the latest updates on recent advancements, will highlight the direct relevance of the course content to the industry.
Technology-facilitated learning (TFL)	Open-source multimedia tools, such as videos and animations, are seamlessly integrated into the course material to elucidate process flows with efficiency and clarity.
Small-group teaching (SGT)	During lectures, group discussions involving approximately six participants will be organized to foster interaction, encourage participation, and facilitate the sharing of knowledge and uncertainties. This format is strategically designed to enhance engagement, sustain attention, and also function as a means of informal feedback on the learning progress.

Assessment Structure

Assessment Components (includes both continuous and summative assessment)

No.	Component	ILO	Related PLO or Accreditation	Weightage	Team/Individual	Rubrics	Level of Understanding
1	Continuous Assessment (CA): Test/Quiz(1. CA1: Quiz 1 (MCQ, short answer questions, and calculation questions))	1-4	EAB Graduate Attributes a, b, c, d, e	40	Individual	Analytic	Relational
2	Continuous Assessment (CA): Assignment(Essay)	1-5	EAB Graduate Attributes a, b, c, d, e, k	60	Individual	Analytic	Extended Abstract

Description of Assessment Components (if applicable)

Formative Feedback

- In-class discussion with students for coordinator to gauge students' understanding and for students to seek clarifications.
- Conduct of written continuous assessments (CA) to measure your learning and progress. The students will be informed of their CA grades.
- Low-stakes discussion during lecture classes to encourage knowledge/ idea sharing amongst peers

NTU Graduate Attributes/Competency Mapping

This course intends to develop the following graduate attributes and competencies (maximum 5 most relevant)

Attributes/Competency	Level
Care for Environment	Intermediate
Care for Society	Intermediate
Creative Thinking	Intermediate

Course Policy

Policy (Academic Integrity)

Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU's shared values. As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the academic integrity website for more information. On the use of technological tools (such as Generative AI tools), different courses / assignments have different intended learning outcomes. Students should refer to the specific assignment instructions on their use and requirements and/or consult your instructors on how you can use these tools to help your learning. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Policy (General)

You are expected to complete all assigned readings, activities, assignments, attend all classes punctually and complete all scheduled assignments by due dates. You are expected to take responsibility to follow up with assignments and course related announcements. You are expected to participate in all project critiques, class discussions and activities.

Policy (Absenteeism)

In-class activities make up a significant portion of your course grade. Absence from class without a valid reason will affect your participation grade. Valid reasons include falling sick supported by a medical certificate and participation in NTU's approved activities supported by an excuse letter from the relevant bodies. There will be no make-up opportunities for in-class activities.

Policy (Others, if applicable)

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