Subject Description Form

Subject Code	ABCT5032
Subject Title	Materials Science for Carbon Neutrality Applications
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	Nil
Objectives	To equip students with the basic concepts, knowledge, and science of materials applied in the latest technologies for carbon neutrality applications. To develop students' ability in providing materials solution to corporate's need for zero-emission goal based on the latest scientific concepts and working principles of materials science.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: a) explain the basic working principles and processes of energy conversion and storage in electrochemical devices, and CO_2 capture and conversion; b) identify key materials used in supercapacitors, rechargeable batteries, fuel cells, heterogeneous catalysis, and CO_2 capture and conversion; c) solve problems associated with the materials used in supercapacitors, rechargeable batteries, fuel cells, heterogeneous catalysis; and CO_2 capture and conversion; d) demonstrate critical skills and analytic ability in the evaluation of materials solution in practical technologies towards zero-emission goal.
Subject Synopsis/ Indicative Syllabus	**Basics of Materials:** Crystalline structure; Atomic structure; Electronic structure. **Materials Science for Electrochemical Supercapacitors:** General principles of electrochemistry; Electric double-layer capacitance and pseudocapacitance; Key electrode materials; Symmetric and asymmetric supercapacitors; Hybrid supercapacitors. **Materials Science for Rechargeable Batteries:** Working principles of several typical types of rechargeable batteries (including but not limited to lithium-ion, sodium-ion, lithium-sulphur, lithium-metal, and lithium-air batteries); Representative cathode and anode materials.

	Materials Science for Green Hydrogen Generation and Utilization: Fundamental electrochemistry and representative materials use in several typical types of fuel cells (including but not limited to solid oxide, direct methanol, and proton exchange membrane fuel cells); Materials for hydrogen storage; Basic thermodynamics and key electrocatalysts for HER. **Materials for Solar Power Utilization:** Basic concepts of semiconductors; Photoelectric conversion (photovoltaic materials); Key materials for artificial photosynthesis. **Materials Science for CO_2 Capture, Storage, and Conversion:** Large-scale CO_2 capture by post-combustion, oxy-fuel combustion and pre-combustion; CO_2 separation by solvent, solid absorbent and membrane; CO_2 storage; materials and principles of electrocatalytic CO_2RR and thermocatalytic CO_2 conversion. **Materials Science for Emerging Sustainable Technologies:** Typical materials for controllable nuclear energy (nuclear fission and fusion), thermoelectric, and piezo/triboelectric energy harvesting technologies. Corrosion and protection of metal materials.
Teaching/Learning Methodology	**Lecture**: The working principles of various kinds of energy conversion and storage processes in electrochemical supercapacitors, rechargeable batteries, fuel cells, and heterogeneous catalysis, as well as CO_2 capture and conversion will be explained, with particular emphasis on the key material issues for the latest developments in those areas. Examples of the emerging sustainable technologies and the basic concepts of machine learning for catalyst design will also be introduced to broaden the vision of the students. **Presentation:** Students will work on a prescribed set of mini-projects and give presentations either individually or in groups. They will be guided in the selection of project topics and reference materials. They are encouraged to identify problems and provide materials solution to a mini-project topic by using their learnt knowledge before seeking assistance. These mini-projects and presentations provide the students with opportunities to consolidate what they have learned and articulate in a well-organized manner.

Assessment Methods in Alignment with Intended Learning Outcomes	see below

Specific assessment methods/tasks	% weighting	Intended subject learning outcomes to be assessed (Please tick as appropriate)					
		a	b	c	d		
1. Continuous Assessment	10%	✓	✓	✓			
2. Presentation	30%	✓			✓		
3. Examination	60%	✓	✓	✓	✓		
Total	100%						

Explanation of the appropriateness of the assessment methods in assessing the intended learning outcomes:

Continuous assessment:

The continuous assessment includes assignments and in-class activities which aim at checking the progress of student study throughout the course, assisting them in fulfilling the learning outcomes.

Assignments, in general, are used to reinforce and assess the concepts and skills acquired by the students; and to let them know the level of understanding that they are expected to reach.

One mid-term test will be administered during the course of the subject as a means of timely checking of learning progress by referring to the intended learning outcomes, and as a means of checking how effective the students digest and consolidate the materials taught in the class.

Mini-projects and oral presentation are used to train the students with the ability to extract useful information from various sources and the ability to present in a clear, logic, and well-organized way.

Examination: This is a major assessment component of the subject. It is a closed-book examination. The emphasis of assessment is to test the understanding, analysis and problem-solving ability of the students.

Student Study Effort Expected		
	Class contact:	
	▪ Lecture	33 Hrs.
	▪ Tutorial	6 Hrs.
	Other student study effort:	
	▪ Self-study	81 Hrs.
	▪	Hrs.
	Total student study effort	120 Hrs.

Reading List and References	Kathy Lu, **Materials in Energy Conversion, Harvesting and Storage**, John Wiley & Sons, 2014. C.D.Rahn and C.-Y.Wang, **Battery Systems Engineering**, John Wiley & Sons, 2013. Ru-Shi Liu *et al.*, **Electrochemical Technologies for Energy Storage and Conversion**, Wiley-VCH Verlag & Co. KGaA, 2012. Wey Yang Teoh *et al.*, **Heterogeneous Catalysts: Advanced Design, Characterization and Applications**, Wiley-VCH, 2021. B.Metz et al., **Carbon Dioxide Capture and Storage**, Cambridge University Press, 2005.