MS4667 Introduction to Sustainable Materials

Academic Year	AY2023-24	Semester	S1
Course Coordinator	Dr. Xiaolei Feng		
Course Type	MPE / BDE / UE		
Pre-requisites	NA		
AU	2		
Grading	Letter Grading		
Contact Hours	26 hours, Lectures 14 hours + Tutorials (including CA & group project) 12 Hours		
Proposal Date	1 March 2023		

Course Aims

The new course will introduce students to the challenges arising from our increased use of materials through the last century or more. Aspects of developing, using and recycling materials in a sustainable way will be explored through a focus on the five key materials that (arguably) have most impact on the environment: steel, cement, aluminum, plastics and paper. This course will be helpful to students keen on building an understanding of the impacts of materials on the environment and, forward looking, the use of materials in ways to secure a sustainable future. This course will also touch on fundamental skills for students interested in policy, decision making and the application of sustainability concepts to modern life**.**

Intended Learning Outcomes (ILO)

By the end of this course, student will be able to:

1. Describe what we are worried about regarding future sustainability as materials scientists/engineers, understand key concepts related to sustainability, understand environmental impacts of our increasing demands of materials, and describe the challenges of making a big difference towards a sustainable future
2. Explain top five key materials that drive the industrial carbon emissions
3. Describe the use of recycled materials – the metals, and to some extent paper and plastics can be recycled which affects sustainability, as the emissions and energy used to recycle these materials is usually much less than to produce fresh material.
4. Describe materials journey, including their flows, stocks and demand.
5. Evaluate the energy and emissions in making materials, like steel.
6. Critically evaluate which processes emit the most greenhouse gases, in response to concerns related to climate change.
7. Explain the factors that limit energy efficiency in materials production and approaches to optimise energy efficiency.
8. Demonstrate knowledge on novel process routes and clean energy that would reduce our total emission.
9. Explain where CO_2 can be stored, what are the risks of storing CO_2, and what the energy and money costs of storing CO_2.
10. Demonstrate their capacity to work in teams, and to network and collaborate with practitioners for real-world problems.

Course Content

No	Topic	Hours
1	Material wealth and health – Why are we worried about a sustainable future? Challenges of making a big difference towards a sustainable future	2
2	Top five materials that drive the industrial carbon emissions – why steel and aluminium are most heavily consumed metals that make Singapore as it is today? use of recycled materials – the metals, and to some extent paper and plastics can be recycled which affects sustainability	3
3	Metal journeys. Flow from ore to final uses. How has the demand built to present levels? What stocks of steel and aluminum goods exist today? How will the demand develop in future?	3
4	CO_2 emissions arising from the material production processes.	3
5	Energy uses in making steel and aluminum components.	3
6	Energy efficiency in existing processes and how to push the limits to future energy efficiency.	3
7	Opportunities for capturing heat.	2
8	Novel process routes and clean energy that would reduce our total emission.	3
9	Carbon sequestration. Where can CO_2 be stored? What are the risks of storing CO_2?	2
10	A special case study	2
	Total	**26**

A guest lecture(s) (at least 2) will be organized on one or two of the teaching weeks depending on the availability of the external speakers. Minor adjustments to the weekly schedule will be done while ensuring all planned topics are covered.

Assessment (Includes both continuous and summative assessment)

Component	ILO Tested	EAB Graduate Attributes	Weightage	Team / Individual	Rubrics
1. Continuous Assessment 1 (CA1): Weekly self-check small quizzes	1-9	a, b, f, g, k, i, j	25%	Individual	N.A. (Standard test)
2. Continuous Assessment 2 (CA2): Mid-term individual poster and peer-review	1-9	a, b, f, g, k, i, j	25% (individual poster – graded by teaching faculty (10%) + Peer-reviews of three other posters (15%))	Individual	Appendix 1
3. Continuous Assessment 3 (CA 3): Group project of a video summary	1-9, 10	a, b, c, d, f, g, k, i, j	50% (45% Group project of a video summary + 5%	Team & Individual	Appendix 2 for Group project of a video

			Feedback on Group members)		summary & Appendix 3 for on Group members)
Total			**100%**		

Description of Assessment Components:

- CA1: Weekly self-check small quizzes (25%)
- CA2: Mid-term individual poster (10%)
- CA2: Peer-reviews of three other posters (15%)
- CA3: Group project of video summary (50%)

The assessment has three components.

CA1: (25%) Weekly self-check small quizzes: small quizzes will be posted on NTULearn course page at regular intervals throughout the course, most likely once per week. They may include multiple-choice questions, true/false questions, or short answer questions. Quizzes are designed to help students monitor their own learning and understanding of the course material, as well as to prepare students for future assessments, including mid-term poster and final video prestation.

CA2: (10%) Individual Poster: Mid-term, students will submit an A3 poster (using the template on the NTULearn home page for the course)

CA2: (15%) Poster Reviews: Each student will write a short peer-review (of no more than 150 words per review) of three other posters (I will allocate reviewers randomly to each poster). The peer-reviews will be marked based on the insightfulness of their suggestions about each poster. To what extent does the review help the author of the poster improve their work? Good reviews will make specific suggestions.

CA3: (45%) Group project: At the end of the course, each group of students will submit a 2.5-3 minutes video summary providing a complete assessment of the suitability of materials for a specific purpose or application, using appropriate graphics and references to support their case.

CA3: (5%) Peer feedback on group work: After submission of CA3 each student will complete a survey reporting their assessment of the contributions made by each of the other members of their group.

EAB Graduate Attributes[1]	
a)	**Engineering Knowledge** Apply the knowledge of mathematics, natural science, engineering fundamentals, and an engineering specialisation as specified in WK1 to WK4 respectively to the solution of complex engineering problems.
b)	**Problem Analysis** Identify, formulate, research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c)	**Design/Development of Solutions**

[1] *Reference: EAB Accreditation Manual*

	Design solutions for complex engineering problems and design systems, components or processes that meet the specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.
d)	**Investigation** Conduct investigations of complex problems using research-based knowledge (WK8) and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
e)	**Modern Tool Usage** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering problems, with an understanding of the limitations.
f)	**The Engineer and Society** Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice and solutions to complex engineering problems.
g)	**Environment and Sustainability** Understand and evaluate the sustainability and impact of professional engineering work in the solution of complex engineering problems in societal and environmental contexts.
h)	**Ethics** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
i)	**Individual and Team Work** Function effectively as an individual, and as a member or leader in diverse teams and in multidisciplinary settings.
j)	**Communication** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
k)	**Project Management and Finance** Demonstrate knowledge and understanding of engineering management principles and economic decision-making, and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
l)	**Life-long Learning** Recognise the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Formative Feedback

Feedback on your design project will be given to project teams during the mid-term consultation. This will help the students in preparing their project report and also the project presentation at the end of the course.

Learning & Teaching Approach

Approach	How does this approach support students in achieving the learning outcomes?
Technology-facilitated learning	Open-source multimedia tools as videos and animations are infused into the course content to decomplexify abstract concepts and processes, available for you to watch both before and after lectures.

Guest lectures	Guest lectures on different subjects provide students with a broad perspective, oriented by material sciences, that integrates the latest advancements and practical problems from the real world
Lecture-based classes	Course content is planned and presented to you in a systematic fashion that will help you to focus on certain key concepts, principles, and ideas. Up-to-date research content.
Embedded self-checking quizzes and enriched case studies	The quizzes allow you to check whether you have mastered key concepts taught in the lectures. It is designed to help you master basic terms, concepts and principles at your own pace. Case studies are also incorporated into the lectures to help create "pauses" in class so that you can reflect upon the course contents and appreciate how they are applied.
Small-group interactive teaching(SGT)	Tutorial sessions are conducted in small groups (20-30 pax) to facilitate interaction and participation amongst you and your tutor. Tutorial questions are designed to (i) keep pace with lecture, (ii) encourage discussions to keep you engaged and (iii) serves as formative feedback to gauge your learning progress.

Readings & References

Textbook
Julian M Allwood & Jonathan M Cullen, *Sustainable Materials without the hot air*, UIT Cambridge Ltd, 2015

Course Policy & Student Responsibility

For CAs, all non-attendance must be supported by a medical certificate or other valid official documents.

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 recognise 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 about the definitions of any of these terms, you should refer to the Academic Integrity Handbook for more information.

Adhering to the university's plagiarism policies, it is unacceptable for students to present a chatbot's response as their own work. Just as it would be unacceptable to copy and paste another person's academic paper, students must ensure that their work is original. However, students may use resources such as ChatGPT for the purpose of learning, but they should not rely on such tools to gain an unfair advantage in their written academic work or submissions. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Course Instructors

Instructor	Office	Phone	Email
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Planned Weekly Schedule

Week	Topic	Course ILO	Readings/Activities
1	Introduction, top five key materials to cut the CO_2 emission	1-2	lecture (2 hrs)
2	Material journey, our uses/demands, use of recycled materials	2-3	lecture (2 hrs) + Tutorial, Group Project, & CA1 (2hrs)
3	Emissions & Energy uses arising from material production	4-5	lecture (2 hrs) + Tutorial, Group Project, & CA1 (2hrs)
4	Energy efficiency in existing processes	6-7	lecture (2 hrs) + Tutorial, Group Project, & CA1 (2hrs)
5	Clean energy, Future energy use	8	lecture (2 hrs) + Tutorial, Group Project, & CA1 (2hrs)
6	Carbon sequestration; opportunities for capturing heat	9	lecture (2 hrs) + Tutorial & Group Project (1 hr) + CA2 (1hr)
7	Case study, summary, revision.	10	Lecture (2 hr) + CA3 Final show and comments of all submitted videos (2hrs)