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

Course Overview

Expected Implementation in Academic Year	AY2025-2026
Semester/Trimester/Others (specify approx. Start/End date)	Semester 1
Course Author * Faculty proposing/revising the course	Leow Wan Ru, Ling Xing Yi
Course Author Email	wanru.leow@ntu.edu.sg; xyling@ntu.edu.sg
Course Title	NANOSCIENCE & NANOTECHNOLOGY
Course Code	CM4063
Academic Units	3
Contact Hours	39
Research Experience Components	Not Applicable

Course Requisites (if applicable)

Pre-requisites	CM3011 or by permission
Co-requisites	
Pre-requisite to	
Mutually exclusive to	CM4014
Replacement course to	
Remarks (if any)	

Course Aims

This course provides a platform to understand small systems, in particular, materials at the nanometer length (10-9 m). In the last few decades, we have witnessed the progress and rise of Nano Age. Upon completing this course, you will understand the foundation and principles of this multidisplinary field, which is the convergence of chemistry, materials, physics, biology and etc. You will also study how nanoscience and nanotechnology help solving global challenges faced by mankind.

Course's Intended Learning Outcomes (ILOs)

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

ILO 1	explain the principles, and foundation of the multi-disciplinary field of nanoscience and nanotechnology
ILO 2	describe the historical background on the development of nanoscience and nanotechnology
ILO 3	explain how nanoscience and nanotechnology are related to your daily life, describe what are the existing products in the market that utilize nanotechnology
ILO 4	describe the advantages of miniaturization
ILO 5	explain what happens at nanoscale, describe what are the expected properties change at nanoscale from the perspectives of surface-to-volume ratio, strength-to-weight ratio, mechanics, electricity, fluids, biology and etc
ILO 6	describe the nanotools available to characterize, image, and examine nanomaterials,
ILO 7	describe the principles of conventional optical microscopy, and explain their advantages and limitations
ILO 8	describe the latest state-of-the-art super-resolution optical imaging technique that allows imaging of single molecule
ILO 9	describe the principles of scanning probe microscopy
ILO 10	explain different types of scanning probe microscopy and their working principles, and describe their advantages and limitations in nanomaterial imaging
ILO 11	describe the principles of electron microscopy
ILO 12	explain different types of electron microscopy and their working principles, and describe their advantages and limitations in nanomaterial imaging
ILO 13	distinguish the various advantages and limitations of the nanomaterial imaging tools, and decide which is the best imaging technique to characterize certain nanostructures
ILO 14	explain metal nanoparticle formation mechanism
ILO 15	describe various methods to synthesize metal nanoparticles
ILO 16	explain the size-dependent catalytic, optical and photothermal properties of metal nanomaterials, and explain how these unique properties can be used for real-life applications

ILO 17	describe various types of carbon nanomaterials, and describe their synthesis or fabrication methods
ILO 18	explain the unique structural, chemical, electrical, electronic, mechanical, and optical properties of carbon nanomaterials, and explain how these unique properties can be used for real-life applications
ILO 19	describe various bottom-up nanochemistry approaches to synthesize and self-assemble (solution-based) nanomaterials
ILO 20	explain the principles and applications of vapor-liquid-solid approach to grow one-dimensional nanowires
ILO 21	explain the mechanism and applications of self-assembled monolayer
ILO 22	explain the principles and applications of supramolecular chemistry
ILO 23	explain the principles and applications of DNA-based self-assembly
ILO 24	explain the mechanism of self-assembly of various nanomaterials and describe their potential applications
ILO 25	describe various top-down nanofabrication approaches to fabricate substrate-based nanomaterials
ILO 26	describe the patterning process of photolithography and various photoresists that can be used to achieve the desired nanostructures, explain the current applications of photolithography and their limitations
ILO 27	describe the working principles of electron-beam lithography and the nanostructures that can be fabricated, explain the advantages and limitations of electron-beam lithography
ILO 28	describe the working principles of focused ion beam lithography and describe the nanostructures that can be fabricated, explain the advantages and limitations of focused ion beam lithography
ILO 29	describe the patterning process of nanoimprint lithography and describe the nanostructures that can be fabricated
ILO 30	describe the working principles of various additive and subtractive processing techniques
ILO 31	distinguish the advantages and limitations of the top-down lithographic approaches and decide which is the best technique to make a pre-defined nanostructure

Course Content

Chapter 1 – Introduction

Chapter 2 – Nanoscale phenomena

Chapter 3 – Nanotools

Chapter 4 – Metal nanomaterials

Chapter 5 – Carbon nanomaterials

Chapter 6 – Nanochemistry

Chapter 7 – Nanofabrication – Top-down techniques

Reading and References (if applicable)

Nanotechnology – Understanding Small Systems, by Ben Rogers, Jesse Adams, Sumita Pennathur, CRC Press, 2007, ISBN-10: 0849382076. Introduction to Nanoscience, by Gabor L. Hornyak, Joydeep Dutta, H.F. Tibbals , Anil Rao, CRC Press, 2008, ISBN-10: 1420048058.

Planned Schedule

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
1	Introduction	1-3		In-person	Lecture, Responseware, Assignment
2	Nanoscale phenomena	4-5		In-person	Lecture, Responseware, Assignment
3	Nanotools	6-9		In-person	Lecture, Responseware
4	Nanotools	10-13		In-person	Lecture, Responseware, Assignment
5	Metal nanomaterials	14-15		In-person	Lecture, Responseware
6	Metal nanomaterials; Review of course contents	16; 1-16		In-person	Lecture, Responseware, Assignment
7	Midterm Test 1	1-16		In-person	Assessment
8	Carbon nanomaterials	17-18		In-person	Online interactive content, LAMS
9	Nanochemistry	19-24		In-person	Online interactive content, LAMS
10	Nanofabrication – Top-down techniques	25-31		In-person	Online interactive content, LAMS
11	Oral presentation	1-31		In-person	Assessment
12	Review of course contents	17-31		In-person	Lecture
13	Midterm Test 2	17-31		In-person	Assessment

Learning and Teaching Approach

Approach	How does this approach support you in achieving the learning outcomes?
Lectures	Face to face lectures will be employed for ILO 1 - 16. This is to allow you to interact directly with the instructor.
Technology-enhanced learning & LAMS	The ILO 17 - 31 will be delivered online. This allows (a) extensive use of animations and laboratory videos and (b) use youreracting This appro this yo uning techeate reflect on free you from the classroom and allows you to address the questions at your convenient and comfortable locations. Moreover, there will be LAMS questions at the end of each chapters, it will allows you to review the knowledge point right after the delivery and to master the knowledge in-depth.
ResponseWare	Allow instructor to challenge you during lecture and to achieve instant feedback. It also allows you to review the knowledge point right after the delivery and to master the knowledge in-depth.
Oral presentation	It is done in a group of 2-4 students, whereby the group members will discuss and select a project on how to make use nanoscience and nanotechnology to resolve the issues that are related to the Singapore government future research and innovation roadmap. The presentation ends with questions and answer session, where I have invited a panel of 5 members to evaluate their performance and ask related questions to probe students' understanding on their topic. The Q&A session is also open to all participants, where all students will be given the opportunity to interact with each other. The learning outcomes of the oral presentation is multiple-pronged. Firstly, the students must learn to work in a group, mimicking their future work place and scenario. Students will need to discuss and come to an agreed topic for discussion. Also, an oral presentation is one of the way to conveys information. This will be important for students as a future worker to present, inform or persuade a new idea product.
Literature review	The aim of literature review is to encourage the students to have more critical thinking - in terms of reading and writing. particular, students are to critically read and identify the purpose of individ lantiala macaouch on the relevant background and re Click to view suggestions For the critical writing part, only when fully understand the context of the article, students are able to evaluate and critique in the quality of the article.

Assessment Structure

Assessment Components (includes both continuous and summative assessment)

No.	Component	ILO	Related PLO or Accreditation	Weightage	Description of Assessment Component	Team/Individual	Rubrics	Level of Understanding
1	Continuous Assessment (CA): Class Participation()	1-31	Competence	10		Individual	Holistic	Multistructural
2	Continuous Assessment (CA): Others(Literature Review)	1-31	Competence	10		Individual	Holistic	Multistructural
3	Continuous Assessment (CA): Test/Quiz(Mid-term Test 1)	1-16	Competence	25		Individual	Holistic	Multistructural
4	Continuous Assessment (CA): Test/Quiz(Mid-term Test 2)	17-31	Competence	25		Individual	Holistic	Multistructural
5	Continuous Assessment (CA): Presentation(Oral Presentation)	1-31	Communication, Competence, Creativity	30		Team	Holistic	Multistructural

Description of Assessment Components (if applicable)

Formative Feedback

You will be given feedback in the following ways:

1. By posting your feedback on the course discussion board.

2. Through face-to-face discussion during the collection of your mid-term paper.

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 Society	Intermediate
Collaboration	Intermediate
Communication	Intermediate
Global Perspective	Intermediate
Critical 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 online activities in good time.

Policy (Absenteeism)

If you miss a lecture, you are expected to make up for the lost learning activities. If you are sick and unable to attend your class, you have to:

send an email to the instructor regarding the absence

submit the Medical Certificate* to the administrator. (* the medical certificate mentioned above should be issued in Singapore by a medical practitioner registered with the Singapore Medical Association.)

There will be no make-up test. If you miss the mid-term test with approval, the marks obtained in all other assessments attempted will be re-scaled to a base of 100%.

Policy (Others, if applicable)

Diversity and Inclusion Policy

Integrating a diverse set of experiences is important for a more comprehensive understanding of science and engineering.

It is our goal to create an inclusive and collaborative learning environment that supports a diversity of perspectives and learning experiences. That honours your identities; including ethnicity, gender, socioeconomic status, sexual orientation, religion or ability.

To help accomplish this:

- If you are neuroatypical or neurodiverse, have dyslexia or ADHD (for example), or have a social anxiety

disorder or social phobia;

- If you feel your performance in the course is being impacted by your experiences outside of class;
- If something was said in the course (by anyone, including instructor/supervisor) that made you uncomfortable.

Please e-mail to your Associate Chair (Students & Continuing Education) at ac-cceb-stud@ntu.edu.sg about how we can help facilitate your learning experience.

As a participant in course discussions you should also strive to honour the diversity of your classmates. You can do this by; using preferred pronouns and names; being respectful of others opinions and actively making sure all voices are being heard; and refraining from the use of derogatory or demeaning speech or actions.

All members of the course are expected to strictly adhere to the student code of conduct (https://www.ntu.edu.sg/life-at-ntu/student-life/student-conduct) . If you witness something that goes against this or have any other concerns, please speak to your instructors or a faculty member.

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Last Updated By: Natasha Bhatia (Dr)