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 2
Course Author * Faculty proposing/revising the course	Prof Raju Ramanujan
Course Author Email	Ramanujan@ntu.edu.sg
Course Title	Magnetic Nanomaterials
Course Code	MS6009
Academic Units	3
Contact Hours	39
Research Experience Components	

Course Requisites (if applicable)

Pre-requisites	
Co-requisites	
Pre-requisite to	
Mutually exclusive to	
Replacement course to	
Remarks (if any)	

Course Aims

The aim of this course is to understand nano magnetic materials and their applications employing a materials science and engineering framework based on processing-structure-property-performance relationships. Bulk magnetic materials will also be covered.

At the end of this course, you will:

1. Obtain an understanding of magnetic materials and their role in modern technological applications.
2. Understand the functional requirements of bulk and nano magnetic materials for various applications.
3. Critically analyse and predict future directions in magnetic materials.

The course will be useful to students who are interested in understanding magnetism from a materials perspective. This course will prepare you for placement with companies engaged in development of bulk or nano magnetic materials, systems, and devices or to continue higher postgraduate studies.

Course's Intended Learning Outcomes (ILOs)

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

ILO 1	Describe the various types of magnetic materials and their physical properties.
ILO 2	Perform materials selection for various applications of bulk and nanomagnetic materials.
ILO 3	Predict the changes in properties on nanostructuring.
ILO 4	Apply the knowledge of unique properties of nanomaterials to specific industry verticals.

Course Content

1. Magnetostatics
    a. Introduction
    b. Magnetic poles
    c. Magnetic moment
    d. Magnetic dipoles
    e. Magnetic effects of currents
    f. Magnetization curves and hysteresis loops.
2. Types of magnetism
    a. Diamagnetism and Paramagnetism
    b. Ferromagnetism
    c. Antiferromagnetic
    d. Ferrimagnetism
3. Types of magnetic materials
    a. Soft magnetic materials.
    b. Applications to electrical machines
    c. Amorphous and nanocrystalline soft magnetic materials
    d. Hard magnetic materials and their applications
4. Magnetic domains
    a. Domain wall structure
    b. Domain wall motion
    c. Magnetization by rotation
    d. Effect of plastic deformation
5. Nanostructured magnetic materials
    a. Amorphous magnets
    b. Single domain versus multidomain behaviour
    c. Coercivity of fine particles
    d. Superparamagnetic
    e. Magnetic thin films
6. Magnetic nanomaterials in bioengineering
    a. Magnetic materials in targeted disease treatment, immunoassay, magnetic resonance imaging.
7. Magnetic nanomaterials for energy applications
    a. Soft magnetic materials for energy generation and conservation
    b. Hard magnetic materials for electrical machines
    c. Magnetocaloric materials and systems
8. Magnetic nanomaterials for information storage
    a. Longitudinal magnetic recording
    b. Perpendicular magnetic recording

9. Magnetic nanomaterials for transducers
    a. Magnet-polymer composites for sensing, actuation and self-healing
    b. Materials design and selection aspects of magnet-polymer composites for bioengineering and structural health monitoring

Reading and References (if applicable)

1. Handbook of magnetic materials, vol. 29, E H Bruck, North Holland (2020).
2. Fundamentals and applications of magnetic materials, K M Krishnan, Oxford Univ Press, U.K.
3. Magnetism and Magnetic materials, J M D Coey, Cambridge Univ Press, U.K.
4. Introduction to Magnetic materials, B D Cullity and C D Graham, IEEE Press, DOI:10.1002/9780470386323

Course Schedule MS6009 Magnetic nanomaterials
(Subject to change)

Teaching Week	Topics or Themes	Readings	Delivery Mode	Activities
1	Introduction. Overview (module 1).	Lecture notes, Self-assessment file.	Online	Pre-recorded lecture
2	Concepts and units (module 2). Self-assessment Set 1 ---- Diamagnetism and Paramagnetism (module 3)	Lecture notes, Self-assessment file.	Online	Pre-recorded lecture, Self-assessment document
3	Ferromagnetism (module 4) Self-assessment Set 2	Lecture notes, Self-assessment file.	Online	Pre-recorded lecture, Self-assessment document
4	Antiferromagnetism (module 5) Ferrimagnetism (module 6). Self-assessment Set 3	Lecture notes, Self-assessment file.	Online	Pre-recorded lecture, Self-assessment document
5	Magnetic Domains (module 7). Hard Magnetic Materials	Lecture notes, Self-assessment file.	Online	Pre-recorded lecture, Self-assessment document

	(module 8). Self-assessment Set 4			
6	CA1	N/A		CA1 Tan Chin Tuan Lecture Theatre (NS4-02-36)
7	CA1: feedback & discussion	N/A	Online	CA1: feedback and discussion
8	Soft magnetic materials (module 9) Nanomaterials (module 10). Self-assessment Set 5	Lecture notes, Self-assessment set file.	Online	Pre-recorded lecture, Self-assessment document
9	Nanomagnetic materials (module 11, part 1) Self-assessment set 6, 7, 8, 9	Lecture notes	Online	Pre-recorded lecture
10	Nanomagnetic materials (module 11, parts 2, 3,4) Self-assessment set 10, 11, 12	Lecture notes	Online	Pre-recorded lecture

11	Applications (module 12). Self-assessment set 13	Lecture notes	Online	Pre-recorded lecture
12	CA2:	N/A		CA2 Tan Chin Tuan Lecture Theatre (NS4-02-36)
13	CA2: feedback & discussion. Recap and dialogue discussion of future trends	N/A	Online	CA2: feedback & discussion. Recap and dialogue with students

Learning and Teaching Approach

Approach	How does this approach support you in achieving the learning outcomes?
On-line lectures	On-line lectures hosted by the Adaptive Teaching and Learning Applications System (ATLAS) will accelerate learning.
On-line assessment	Three continuous assessments will be conducted on-line through the semester.
Demonstrations and Prerecorded lectures by guest speakers	The demonstrations of instrumental techniques and sophisticated applications and lectures by guest speakers will provide valuable insight into experimental methodology and topics of current interest.

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): Test/Quiz(CA1: Quiz)	1, 2, 3	N/A	30		Individual	Holistic	Multistructural
2	Continuous Assessment (CA): Test/Quiz(CA2: Quiz)	1, 2, 3	N/A	30		Individual	Holistic	Relational
3	Continuous Assessment (CA): Presentation(CA3: Group Presentation (with Q&A))	1, 2, 3, 4	N/A	40		Team	Holistic	Multistructural

Description of Assessment Components (if applicable)

CA1: Individual quiz

CA2: Individual quiz

CA3: You are required prepare a pre-recorded presentation on a topic related to the course content and present it, followed by Q &A. The group size can be a max of 8 students. The presentation should be at the postgraduate level and presented in a coherent, interesting, and visually appealing manner (graphics, animation, videos etc). You should take effort to explain the material. You are required to answer questions related to your presentation. For example, you can choose an excellent research paper (or papers or book) related to magnetic materials published in a prestigious journal in the last 10 years and which has attracted many citations. Your presentation should contain the following elements: Introduction to the topic, description of the contents of the paper, novelty and significance of the paper, limitations of the paper and scope for future work. Add references. The presentation should be properly divided among the group members in terms of content so that there is good group dynamics. A critical assessment of the paper is needed, do not just “cut and paste” from the paper.

Formative Feedback

You will receive formative feedback for the CAs after submission. Time has been allotted for the feedback.

You can proactively approach me or the TA regarding the tutorial questions and solutions.

You will receive summative group feedback on your performance following the conclusion of the module.

NTU Graduate Attributes/Competency Mapping

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

Attributes/Competency	Level
Collaboration	Intermediate
Communication	Advanced
Problem Solving	Advanced
Information Literacy	Advanced
Critical Thinking	Advanced

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.

You should note the schedule of the assessments before the end of the add-drop period and block these timings.

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)

This graduate course requires a high level of discipline and continuous effort to succeed. You are encouraged to form study groups with your peers and access the many sources of on-line information related to the course content. As the emphasis is on understanding, rather than memorisation, all CAs are open-book and you can use whatever resources will enable you achieve a high grade.

Last Updated Date: 08-09-2025 18:09:12

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