Course Requisites (if applicable)

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

Course Aims

This course aims to introduce the fundamental physical concepts of spin electronics and their applications in technology. Students who are interested in the research of spintronics are recommended to take this course. It is also helpful in increasing the chances of students getting hired in the magnetics/spintronics industry. This course is self-contained and there are no prerequisites.

Course's Intended Learning Outcomes (ILOs)

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

ILO 1	Understand the fundamental of magnetism
ILO 2	Understand micromagnetism, magnetic textures, and magnetization dynamics
ILO 3	Understand spin transport and dynamics in real materials
ILO 4	Familiar with spintronics technology
ILO 5	Be aware of the frontier of recent research

Course Content

In the course, we will include:

1. History of Spintronics and Magnetism

- History and overview
- Classical and quantum spin
- Spin-orbit interaction
- Spintronics and magnetism

2. Introduction to magnetic moment

- Magnetism and filed
- Classical magnetic moment
- Quantum magnetic moment

3. Isolated magnetic moment

- Magnetic susceptibility
- Diamagnetism
- Paramagnetic
- Hund's rules
- Adiabatic demagnetization
- Nuclear spins
- Hyperfine structure

4. Environment

- Crystal field
- Orbital Quenching
- The Jahn-Teller effect
- Nuclear magnetic resonance
- Electron spin resonance

5. Interactions

- Magnetic dipolar interaction
- Exchange interaction
- Origin of exchange
- Direct exchange
- Indirect exchange
- Double exchange
- Anisotropic exchange
- Continuum approximation

6. Order and magnetic structure

- Ferromagnetism
- Antiferromagnetic
- Ferrimagnetism
- Helical order
- Measurement of magnetic order

7. Orders and broken symmetry

- Broken symmetry
- Landau theory
- Heisenberg and Ising Model
- Consequence of broken symmetry
- Phase transition
- Rigidity
- Excitations
- Domains

8. Magnetism in metals

- The free electron model
- Pauli paramagnetic
- Spin-split bands
- Spin-density functional theory
- Landau Level
- Landau diamagnetism
- Spin density wave

9. Recent advances in research

- Topological materials
- Skyrmions
- Spin-orbit torque
- Spin caloritronic
- Magnonics

Reading and References (if applicable)

- Magnetism in condensed matter, Stephen Blundell Oxford Master Series in Physics
- Introduction to Magnetism and Magnetic Materials, D. Jiles, Chapman & Hall, 1998.

Planned Schedule

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
1	Introduction	1	Lecture notes, textbooks (see “Reading and References”)	In-person	
2	Magnetism in materials	2	Lecture notes, textbooks (see “Reading and References”)	In-person	
3	Magnetism in materials	2	Lecture notes, textbooks (see “Reading and References”)	In-person	
4	Spin relaxation and transport	3	Lecture notes, textbooks (see “Reading and References”)	In-person	
5	Spin relaxation and transport	3	Lecture notes, textbooks (see “Reading and References”)	In-person	
6	Spin relaxation and transport	3	Lecture notes, textbooks (see “Reading and References”)	In-person	
7	Spintronics for Information Technology	4	Lecture notes, textbooks (see “Reading and References”)	In-person	
8	Spintronics for Information Technology	4	Lecture notes, textbooks (see “Reading and References”)	In-person	
9	Magnetic Random Access Memory	4	Lecture notes, textbooks (see “Reading and References”)	In-person	
10	Magnetic Random Access Memory	4	Lecture notes, textbooks (see “Reading and References”)	In-person	
11	Seminar: Recent advances in research	5	Self-reading on research papers	In-person	
12	Seminar: Recent advances in research	5	Self-reading on research papers	In-person	
13	Seminar: Recent advances in research	5	Self-reading on research papers	In-person	

Learning and Teaching Approach

Approach	How does this approach support you in achieving the learning outcomes?
Lecture	You will be introduced to fundamental physical concepts of spin electronics and the application in technology via the lectures. Lectures will be used to fill in detail and allow students opportunities for questioning and critique.
Student presentations	You will present your research and findings to the whole class. This supports peer-learning as well as developing research and presentation skills.
Project work	You will engage in project work during class time, under guidance from the instructor. This will permit sharing of ideas amongst students and instant feedback on project work.
Technology-Enhanced Learning (TEL)	This course will use PowerPoint slides with videos embedded and lecture recordings to enhance learning.

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): Class Participation(Class participation)	1, 2, 3, 4		20	Individual	Analytic	Not Applicable
2	Continuous Assessment (CA): Presentation(CA1: Presentation)	5		40	Individual	Holistic	Extended Abstract
3	Continuous Assessment (CA): Others(CA2: Project report)	1, 2, 3, 4, 5		40	Individual	Holistic	Extended Abstract

Description of Assessment Components (if applicable)

Class participation (20%):

Questionnaires will be distributed to you during lecture to collect your responses. This is to check your overall understanding of the lecture. The answers will not be assessed, only the participation counts.

CA1 (40%):

You have to read up on research papers and summarize the recent research progress into a presentation.

CA2 (40%):

The project report contains 2 parts. The first part will be a review of the frontier research and the second part will be your proposal on what could be done in the next 5-10 years.

Formative Feedback

You will receive both written and verbal feedback from me about your presentations and final research project report.

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
Curiosity	Advanced
Ethical Reasoning	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 pre-class readings and activities, attend all seminar classes punctually and take all scheduled assignments and tests by due dates. You are expected to take responsibility to follow up with course notes, assignments, and course related announcements for seminar sessions they have missed. You are expected to participate in all seminar discussions and activities.

Policy (Absenteeism)

Absence from class without a valid reason will affect your overall course 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.

Policy (Others, if applicable)

Last Updated Date: 13-02-2025 01:48:19