

# **ECE5332 007 – Topics in Electrical Engineering: Introduction to Magnetic Materials**

Fall 2024

Department of Electrical and Computer Engineering, Texas Tech University

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**Instructor:** Dr. Kai Wu

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**Tel:** 806-834-0778

**Class Meeting Time:** M, W, F 10:00 am – 10:50 am

**Classroom:** Engineering Center 00110

**Office Hours:** Friday 11 am – 12 pm, Location ECE 234

**Class Website:** Blackboard

## **Textbooks:**

“Introduction to Magnetic Materials” (2nd Edition) B.D. Cullity and C.D. Graham.

Lecture slides will be distributed on Blackboard.

## **Course Overview:**

Principals of quantum mechanics and band theory. Physics of diamagnetism, paramagnetism, ferromagnetism, antiferromagnetism, ferrimagnetism, and associated properties. Instruments for measuring material magnetic properties. Static and dynamic theory of micromagnetics, magnetic particles and thin films, and other emerging magnetic materials.

## **Course Outcomes:**

1. A solid understanding of the distinction between fundamental types of magnetism, such as diamagnetism, paramagnetism, ferromagnetism, ferrimagnetism, and antiferromagnetism, and their relationship to quantum mechanics.
2. General understanding and ability to perform simple calculations on secondary phenomena such as magnetic anisotropy, magnetostriction, and spin transport.
3. Have a general understanding of micromagnetic phenomena such as domain walls and hysteresis loops and the ability to perform simple calculations.
4. Ability to use micromagnetic simulation tool OOMMF for modeling dynamic magnetization of materials.

## **Methods of Assessment of Learning Outcomes**

The learning outcome will be evaluated based on students’ performance in homework, individual presentations, and micromagnetic simulation projects.

## Grading:

- Homework: 75%

Homework is assigned bi-weekly.

Students are expected to write a 1-page summary of research papers distributed by the instructor every other week.

Homework is due one week after the assignment date.

**Five homework assignment dates: Sep 6, Sep 20, Oct 4, Oct 18, Nov 8.**

- Midterm Projects: 0%

OOMMF code will be provided.

- Final Presentation: 25%

Each student picks one research paper to present in class, a 12-minute talk + 3-minute Q&A.

**Student final presentation dates: Nov 18, Nov 20, Nov 22, Nov 25.**

**In the week of Nov 11, students will pick their preferred final presentation dates.**

## Course Outline:

1. Introduction (1 lecture)
2. Quantum Mechanisms and Band Theory (2 lectures)
3. Origin of Magnetization (2 lectures)
4. Definition and Units (2 lectures)
5. Demagnetization and Magnetic Shielding (1 lecture)
6. Instruments for Measuring Magnetizations (1 lecture)
7. Diamagnetism (1 lecture)
8. Paramagnetism (1 lecture)
9. g-factor (1 lecture)
10. Ferromagnetism (2 lectures)
11. Antiferromagnetism (1 lecture)
12. Ferrimagnetism (1 lecture)
13. Magnetic Anisotropy (3 lectures)
14. Magnetostriction (1 lecture)
15. Magnetic Domains and Domain Walls (2 lectures)
16. LLG Equation (2 lectures)
17. Micromagnetic Simulation: OOMMF (3 lectures)
18. Spintronics: Basics (2 lectures)
19. Special Topics: Magnetic Nanoparticles, Magnetic Imaging, Magnetic Sensors, Spintronic Devices, etc. (4 lectures)

### Class Schedule

Monday	Wednesday	Friday
		Aug 23 Introduction
Aug 26 Quantum Mechanisms and Band Theory	Aug 28 Quantum Mechanisms and Band Theory	Aug 30 Origin of Magnetization
Sep 2 Labor Day Holiday	Sep 4 Origin of Magnetization	Sep 6 (HW1 Assignment) Definition and Units
Sep 9 Definition and Units	Sep 11 Demagnetization and Magnetic Shielding	Sep 13 Instruments for Measuring Magnetizations
Sep 16 Diamagnetism	Sep 18 Paramagnetism	Sep 20 (HW2 Assignment) g-factor
Sep 23 Ferromagnetism	Sep 25 Ferromagnetism	Sep 27 Antiferromagnetism
Sep 30 Ferrimagnetism	Oct 2 Magnetic Anisotropy	Oct 4 (HW3 Assignment) Magnetic Anisotropy
Oct 7 Magnetic Anisotropy	Oct 9 Magnetostriction	Oct 11 Magnetic Domains and Domain Walls
Oct 14 Magnetic Domains and Domain Walls	Oct 16 LLG Equation	Oct 18 (HW4 Assignment) LLG Equation
Oct 21 Micromagnetic Simulation: OOMMF (Zoom)	Oct 23 Micromagnetic Simulation: OOMMF (Zoom)	Oct 25 Micromagnetic Simulation: OOMMF (Zoom)
Oct 28 Midterm Project (no class)	Oct 30 Midterm Project (no class)	Nov 1 Midterm Project (no class)
Nov 4 Spintronics: Basics	Nov 6 Spintronics: Basics	Nov 8 (HW5 Assignment) Special Topics
Nov 11 Special Topics	Nov 13 Special Topics	Nov 15 Special Topics
Nov 18 Student Final Presentation	Nov 20 Student Final Presentation	Nov 22 Student Final Presentation
Nov 25 Student Final Presentation	Nov 27 Thanksgiving Holiday	Nov 29 Thanksgiving Holiday
Dec 2 No Class		

## Safety and Wellness

The Texas Tech University (TTU) and Edward E. Whitacre Jr. College of Engineering are committed to the safety and wellness of our students by providing various services and resources.

Make sure you register with [Tech Alert](#) to get emergency notification by phone call, text, or email. You are encouraged to review the [Emergency Action Plans \(EAPs\)](#) and watch the videos of [Know What To Do In Emergency Events](#) and [Surviving an Active Shooter Event Training](#) to be prepared for those emergency situations. Additionally, due to the nature of laboratory or design courses, it is mandatory for you to follow the [university safety policies](#) and any additional safety protocols required by the course instructor(s).

For your wellbeing, various services are available at [Student Counseling Center](#) and [Student Health Services](#). The Student Wellness Center provides convenient walk-in services M-F from 8 AM to 5 PM. Furthermore, the Texas Tech Crisis HelpLine (806-742-5555) provides 24/7/365 assistance for students experiencing a crisis or distress.

Emergency/Crisis Phone Number

TTU Police (UPD) Emergency	911
TTU Police (UPD) Non-Emergency	806.742.3931
TTU Emergency Maintenance	806.742.4OPS (4677)
TTU EHS (M-F, 8 am – 5 pm)	806.742.3876
SafeRide	806.742.RIDE (7433)
TTU Crisis HelpLine	806.742.5555
Student Wellness Center (From Urgent Care to a Full-Service Pharmacy on site)	806.742.2848
Title IX Reporting	806.742.7233
The Dean of Students	806.742.2984