

ECE5332 001 – Topics in Electrical Engineering: Spintronic Devices and Applications

Spring 2023

Department of Electrical and Computer Engineering, Texas Tech University

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Class Meeting Time: M, W, F 9:00 am – 9:50 am

Classroom: ECE 118

Office Hours: Friday 10 am – 11 am

Class Website: Blackboard

Textbooks:

“Modern Magnetic Materials: Principles and Applications” Robert C. O’Handley

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

Lectures slides will be distributed on Blackboard.

Course Overview:

Basic concepts and physical principles underlying spintronic devices; engineering designs and basic features of matured spintronic devices: giant magnetoresistance (GMR), magnetic tunnel junction (MTJ) sensor, magnetoresistive random-access memory (MRAM), etc; new opportunities and engineering designs and challenges of spintronic devices: STT-RAM, spin torque oscillator (STO) and all spin logic, etc.

Course Outcomes:

Students successfully completing this course are expected to understand the fundamentals of analysis and engineering design of spintronic devices as well as underlying physical principles. Students will be able to use micromagnetic simulation tool OOMMF for modeling some spintronic devices.

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: 60%

Mid-term Project: 20%

Final Presentation: 20%

Homework assignments will be on a bi-weekly basis.

Preliminary Course Outline (42 lectures):

1. Introduction (1 lecture)
2. Definition And Units (2 lectures)
3. Magnetic Materials (4 lectures): Diamagnetism, paramagnetism, ferromagnetism, ferrimagnetism, antiferromagnetism
4. Magnetic Anisotropy (3 lectures): crystal and shape anisotropy
5. Magnetostriction (1 lecture)
6. Magnetic Domains and Domain Walls (2 lectures)
7. Magnetic Dynamics (3 lectures): LLG equation
8. Spintronics (6 lectures): Magneto-resistance effects; Two channel model; Spin accumulation, Spin diffusion, Spin scattering, Spin relaxation, Spin injection.
9. Micromagnetic Simulation (3 lectures): OOMMF
10. Giant Magnetoresistance (GMR) and Magnetic Tunnel Junction (MTJ): structures and devices (3 lectures)
11. Spin Hall Effect (SHE): physics and devices (1 lecture)
12. Spin transfer torque (STT): physics and devices (1 lecture)
13. Spin Torque Oscillator (STO): physics and devices (1 lecture)
14. Magnetic Biosensors (3 lectures): GMR, MTJ, NMR, MPS, STO, etc.
15. Advanced Topics (3 lectures): Covering most recent papers on magnetic and spintronic nanodevices such as magnetoelectric switching devices; magnetic domain devices; magnetic skyrmions, etc.

Class Schedule

Monday	Wednesday	Friday
	Jan 11 <u>Introduction</u>	Jan 13 <u>Definition and Units</u>
Jan 16 MLK day (no class)	Jan 18 <u>Definition and Units</u>	Jan 20 <u>Magnetic Materials</u>
Jan 23 <u>Magnetic Materials</u>	Jan 25 <u>Magnetic Materials</u>	Jan 27 <u>Magnetic Materials</u>
Jan 30 <u>Magnetic Anisotropy</u>	Feb 1 <u>Magnetic Anisotropy</u>	Feb 3 <u>Magnetic Anisotropy</u>
Feb 6 <u>Magnetostriction</u>	Feb 8 <u>Magnetic Domains</u>	Feb 10 <u>Magnetic Domains</u>
Feb 13 <u>Magnetic Dynamics</u>	Feb 15 <u>Magnetic Dynamics</u>	Feb 17 <u>Magnetic Dynamics</u>
Feb 20 <u>Spintronics</u>	Feb 22 <u>Spintronics</u>	Feb 24 <u>Spintronics</u>
Feb 27 <u>Spintronics</u>	Mar 1 <u>Spintronics</u>	Mar 3 <u>Spintronics</u>
Mar 6 <u>Micromagnetic Simulation</u>	Mar 8 <u>Micromagnetic Simulation</u>	Mar 10 <u>Micromagnetic Simulation</u>
Mar 13 (Spring Break, no class)	Mar 15 (Spring Break, no class)	Mar 17 (Spring Break, no class)
Mar 20 <u>GMR and MTJ</u>	Mar 22 <u>GMR and MTJ</u>	Mar 24 <u>GMR and MTJ</u>
Mar 27 <u>SHE</u>	Mar 29 <u>STT</u>	Mar 31 <u>STT</u>
Apr 3 <u>STO</u>	Apr 5 STO	Apr 7 <u>Magnetic Biosensors</u>
Apr 10 (TTU calendar, no class)	Apr 12 <u>Magnetic Biosensors</u>	Apr 14 <u>Magnetic Biosensors</u>
Apr 17 <u>Advanced Topics</u>	Apr 19 <u>Advanced Topics</u>	Apr 21 <u>Advanced Topics</u>
Apr 24 <u>Student Final Presentation</u>	Apr 26 <u>Student Final Presentation</u>	Apr 28 <u>Student Final Presentation</u>
May 1 (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