

# Magnetic Materials & Devices

EE 396V (Unique ID 17820)/379K (Unique ID 17544) Spring 2021 (MW 3-4:30p Virtual)

## Instructor

Instructor	Email	Office Location & Hours
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Teaching Assistant	Email	Office Location & Hours
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## General Information

### Description

Magnetic materials play a key role in both present and future computing for storage and logic. This course will provide a foundation for understanding the materials, physics, and engineering behind magnetic devices. It will start with the fundamentals of magnetic materials, including both classical and quantum descriptions of the origin of magnetism in oxides and metals. We will discuss the different energies at play in magnetic materials such as demagnetization energy, magnetocrystalline anisotropy, exchange energy, and dipolar coupling. We will describe magnetic switching mechanisms and how spin structures arise, such as domain walls and topologically-protected skyrmions. By the end of the course, we will be able to understand existing breakthrough magnetic devices, as well as emerging phenomena that could be applied to future memory and logic devices.

This course is a combined graduate (396V)/upper-division undergraduate (379K) course. The students will learn the same concepts; the graduate version will have extra problems assigned and a more involved final project than the undergraduate version.

### Tentative Course Topics

- Review of Maxwell's equations and of classical and quantum origins of magnetism
- Spin-orbit coupling and exchange interactions in ferromagnets
- Magnetic oxide structures such as ferrites, perovskites, and garnets
- Spin structures such as domain walls and skyrmions
- Magnetic reversal mechanisms including spin torque effects
- Magnetic devices such as giant magnetoresistance and tunnel magnetoresistance recording heads, hard drives, and spin transfer torque magnetic random access memory
- Possibilities for future devices including memory/logic devices, multiferroic materials, spins in 2D materials, and magneto-optical devices

### Class Hours and Location

MW 3pm-4:30pm

Location: Virtual via Zoom

### Prerequisites

**396V Graduate Version:** Graduate. Undergraduate quantum mechanics recommended, undergraduate electricity and magnetism required (experience working with calculus-based Maxwell's Equations).

**379K Undergraduate Version:** A grade of C- or higher in EE 325 Electromagnetic Engineering and M 427L Advanced Calculus for Applications II (Vector Calculus), or consent of the instructor.

## Textbooks

### Main Textbook

R.C. O’Handley, Modern Magnetic Materials, Wiley 2000 (ISBN 0-471-15566-7) (Recommended, but not required)

### Suggested Textbooks

S. Bandyopadhyay and M. Cahay, Introduction to Spintronics, 2nd Ed., CRC Press 2016 (ISBN: 978-1482255560)

B.D. Cullity and C.D. Graham, Introduction to Magnetic Materials, 2nd Ed., Wiley 2009 (ISBN: 978-0-471-47741-9)

D. Jiles, Introduction to Magnetism & Magnetic Materials, 2nd Ed., Chapman & Hall 1998 (ISBN: 0-412-79860-3)

N. Spaldin, Magnetic Materials Fundamentals and Device Applications. Cambridge 2003 (ISBN 0 521 01658 4)

G.F. Dionne, Magnetic Oxides. Springer, 2009 (ISBN 978-1-4419-0053-1)

## Additional Information

### Grading

23% Homework, 25% Midterm 1, 25% Midterm 2, 25% Final Paper/Presentation (15% paper, 10% presentation), 2% Class participation. Plus and minus letter grades may be assigned. Request for regrading an assignment must be made in writing within one (1) week of the graded assignment being made available to students in the class. Late assignments will not be accepted, but the one (1) lowest homework grade will be dropped.

Midterms will be curved; the curve will be discussed in class. All other assignments will not be curved.

### Add/Drop Policy

An engineering student must have Dean’s approval to add/drop after the fourth class day of the semester.

### Academic Honesty

You are encouraged to work in small groups for problem sets. However, please submit your own independent solutions. Plagiarism or any form of academic dishonesty (cheating includes, but is not limited to, copying another student’s work, bringing notes into a test and copying material directly from a book, article or web site without including appropriate references, falsifying data, doing someone’s work) is a violation of University rules and may return a grade of zero for each assignment in which it is detected or may incur even steeper penalties. For University policies see:

<http://deanofstudents.utexas.edu/conduct/academicintegrity.php>

### Students with Disabilities

UT provides upon request appropriate academic accommodations for qualified students with disabilities. Disabilities range from visual, hearing, and movement impairments to ADHD, psychological disorders (e.g. depression and bipolar disorder), and chronic health conditions (e.g. diabetes and cancer). These also include from temporary disabilities such as broken bones and recovery from surgery. For more information,

contact Services for Students with Disabilities at (512) 471-6259 [voice], (866) 329-3986 [video phone], [ssd@uts.cc.utexas.edu](mailto:ssd@uts.cc.utexas.edu), or <http://ddce.utexas.edu/disability>.

### **Mental Health Counseling**

Counselors are available Monday-Friday 8am-5pm at the UT's Counseling and Mental Health Center (CMHC) on the 5th floor of the Student Services Building (SSB) in person and by phone (512-471-3515). The 24/7 UT Crisis Line is 512-471-2255.

### **Accommodations for Religious Holidays**

Section 51.911 states that a student shall be excused from attending classes or other required activities, including examinations, for the observance of a religious holy day, including travel for that purpose. A student whose absence is excused under this subsection may not be penalized for that absence and shall be allowed to take an examination or complete an assignment from which the student is excused within a reasonable time after the absence. University policy requires students to notify each of their instructors as far in advance of the absence as possible so that arrangements can be made. By UT Austin policy, you must notify the instructor of your pending absence at least fourteen days prior to the date of observance of a religious holiday.

### **Campus Carry**

The University of Texas at Austin is committed to providing a safe environment for students, employees, university affiliates, and visitors, and to respecting the right of individuals who are licensed to carry a handgun as permitted by Texas state law. For more information, please see <http://campuscarry.utexas.edu/students>.

### **Recommendations Regarding Emergency Evacuation from the Office of Campus Safety and Security (<http://www.utexas.edu/safety/>)**

- Occupants of buildings on The University of Texas at Austin campus are required to evacuate buildings when a fire alarm is activated. Alarm activation or announcement requires exiting and assembling outside.
- Familiarize yourself with all exit doors of each classroom and building you may occupy. Remember that the nearest exit door may not be the one you used when entering the building.
- Students requiring assistance in evacuation shall inform their instructor in writing during the first week of class.
- In the event of an evacuation, follow the instruction of faculty or class instructors; exit in an orderly fashion and assemble outside.
- Do not re-enter a building unless given instructions by the following: Austin Fire Department, The University of Texas at Austin Police Department, or Fire Prevention Services office.
- Behavior Concerns Advice Line (BCAL): 512-232-5050
- Link to information regarding emergency evacuation routes and emergency procedures can be found at: <http://www.utexas.edu/emergency>