Electronic, Optical and Magnetic Properties of Materials

Course #: MSE 3015

- **Credit hours:** 3
- **Pre-requisites:** Phys 2212 and MSE 2001, or consent of instructor

Instructor: Prof. Lauren M. Garten

Course Supplies:

- **Book**: O. Kasap, *Principles of Electronic Materials and Devices*, 3rd/4th Edition, McGraw-Hill, Boston and Chicago, 2006/2018
- **Computer: (If remote work is necessary)** you must have a laptop or desktop computer (not a tablet or phone) with a working web-cam and microphone.

Course Description: This course provides the framework needed to understand the electrical, optical, and magnetic properties exhibited by different materials (ceramics, polymers, metals, thin films, etc.). The course begins with a classical model of conductivity and then develops progressively more realistic models by introducing quantum mechanics and structure-property relationships. These models will then be expanded to describe the optical and magnetic response of each material class as well. Specific focus will be given on semiconductors, metals, dielectrics, ferromagnets, and superconductors. For each section the materials properties will be related to the operations of solid-state electronic, optical, and magnetic devices - the basis of modern microelectronics and nanotechnologies.

Learning Objectives:

- Demonstrate understanding of the electrical properties of metals, semiconductors, and dielectrics and applications of these properties in modern electronic devices.
- Demonstrate how the behavior of electrons and nuclei in solids defines the electrical response of a material by answering questions and solving relevant problems.
- Demonstrate understanding of the optical properties of materials and applications of these properties in operation of modern optical and electro-optical devices.
- Demonstrate an understanding of the magnetic properties of materials and their applications.

Grading Policy:

Assessment	Total #	Policy	Final #	Grade Percentage
In Class Assessments	13	Drop lowest	12	20
Homework	6	Optional	-	-
Project	1	Group work	1	20
Exams	2	-	2	40
Final	1	-	1	20

- **In-class Assessments:** Students will work either individually or in groups to answer example questions on the information discussed in previous lectures. In-class work will be graded based on accuracy. Answers to all questions are required for full points. At least one line of reasoning or calculations for each question is required for full points.
- **Project:** "Perplex the Professors" (out of 100 pts)
    - Students will work in small groups (~5 people) to identify an engineered material, relevant to or taken from an electrical, optical, or magnetic device (solid state only, no liquids or amorphous materials).
    - Each group will bring their selected material to a panel of professors on the day the project is due (11/30)
    - Prior to the judging, each group must have researched and prepared a 3 page report including:
        - The materials composition, crystal structure, processing or fabrication method
        - A description of its electrical, optical, and magnetic properties, (i.e. intrinsic semiconductor, indirect bandgap Eg = 2 eV, paramagnetic) with references.
        - A description of the application in which the material is used and the *figure of merit* for that material in that application.
        - Each student should add a brief summary of their contribution to the report at the end of the write up.

    - The professor panel will then have to guess the material system (the primary chemical constituents or materials class) and the materials application (the generic device type). The professors will be allowed a set of simple hand tools. The guesses from the professors will then be compared to the results provide from the group.
    - If a student group can stump the professors (the professors cannot answer the two questions outlined above), then the students in that group will receive +10 pts extra points on the assignment. If the professors can only guess one question, that group will receive +5 pts.

- **Homework:** The homework is optional. It will be provided on Canvas. Homework should be used to learn and practice. The homework will not be graded; solutions will be provided after the submission date.

- **Testing policy**
    - There will be two midterms and a final.
    - The final is not cumulative (but will still require a strong understanding of all previous material).
    - Tests will be closed notes and books.
    - A generic equation sheet and periodic table will be provided prior to the test.
    - You can use your own scientific calculator, however, there should be no information stored on the calculator. The RAM should be cleared prior to the test. Do not use your mobile phone or laptop as a calculator.
    - Be sure to put **your name** on the top of each sheet on the top right corner.
    - (**If remote work is necessary**) Your test environment should mimic an in-class test environment. There should be no papers, books, or other materials on your desk or near you. Your mobile phone should be stored (e.g. in a drawer) but should be near you to use at the end of the test to take a picture of your answer sheets. On the scheduled day/time of the test, log onto the Teams classroom. Do not log off of Teams until you have submitted your answers via the Canvas quiz as described below. Your microphone and camera should be on and focused on you at all times. Once the test starts, you may mute your speaker volume if you like. Open Canvas, go to Quizzes, but DO NOT START THE TEST UNTIL YOU ARE TOLD TO DO SO. Once you are told to start you will have a total of 80 minutes to

complete the mid-terms, of the sheets and upload the sheets to Canvas. You should not speak or communicate with anyone else while taking the test. You can use the Teams chat function if you have questions for me about the test. Once you have finished all of the problems on the blank paper, you can then take out your phone (or use a scanner located on your desk) to take a picture of each sheet. You should no longer write on your answer sheets after you take the pictures of the sheets.

- **Grade Accuracy:** Errors in grading and/or recording of scores for assignments and exams must be addressed within 7 days of posting on Canvas by contacting the instructor in writing via email. Disputes after this one-week period will not be considered.
- **Attendance and/or Participation:** Attendance is not mandatory, but students are responsible for all material presented, any announcements made during lectures, and must take the exam during the scheduled time unless there is a legitimate conflict (see below).
- **Academic Integrity:** Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards. For information on Georgia Tech's Academic Honor Code, please visit http://www.catalog.gatech.edu/policies/honor-code/ or http://www.catalog.gatech.edu/rules/18/. Any student suspected of cheating or plagiarizing on a quiz, exam, or assignment will be reported to the Office of Student Integrity, who will investigate the incident and identify the appropriate penalty for violations.