

Syllabus – ME/MSE 6796

Structure-Property Relationships in Materials

ME/MSE 6796, Fall 2026, Credits: 3-0-3

Lecture: TR, 2:00 – 3:15 pm, MRDC 3403

Instructor: Prof. Matthew McDowell (he/him)

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Office Hours: As needed

General Information

Description

This course introduces students to the relationship between atomic bonding, crystallographic symmetry, and properties of materials. Using the knowledge developed throughout this course, students will be able to design materials with optimal microstructure for a given application.

Pre-Requisites: Graduate standing in engineering or a related discipline.

Course Materials

Course Texts

Properties of Materials: Anisotropy, Symmetry, Structure. Robert E. Newnham, Oxford University Press, 2005.
(Available digitally via GT Library)

Materials Engineering: Bonding, Structure, and Structure-Property Relationships. Susan Trolier-McKinstry, Robert E. Newnham, Cambridge University Press, 2017. (Useful, but not required)

Physical Properties of Crystals: Their Representation by Tensors and Matrices. J. F. Nye, Oxford University Press, 1985. (Useful, but not required)

Course Website and Other Classroom Management Tools

All class updates, announcements, discussion, and grades will be posted on **Canvas**.

Grading

Grade Allotment

Homework: 20%
Exam 1: 35%
Exam 2: 35%
Final Project 10%

Grading Scale

Your final grade will be assigned as a letter grade according to the following scale:

A	89.5%-100%
B	79.5-89.4%
C	64.5-79.4%
D	49.5%-64.4%
F	0-49.4%

Course Outline

Topic

Interatomic bonding

Review of crystallography and crystal symmetry

Tensor descriptions of materials properties

Tensor transformations

First and second rank tensors, associated properties

Stress and strain

Piezoelectricity and third rank tensors

Elasticity

Survey of other properties

Course Goals and Learning Outcomes

Upon successful completion of this course, you will have learned to perform the following tasks:

1. Understand how interatomic bonding impacts materials properties
2. Predict how atoms will arrange into crystals based on their bonding characteristics
3. Determine how the symmetry of material properties is affected by crystallographic symmetry
4. Use tensors to describe materials properties
5. Understand when and why to use first, second, third, and fourth rank tensors to describe properties
6. Describe the key features of different materials properties and how these properties are defined mathematically
7. Explain symmetry of polycrystalline materials, and the relationship between single crystals and polycrystals in the context of materials properties
8. Explain how properties of a material are determined by bonding characteristics, crystal structure, symmetry, and microstructure
9. Design a material (composition, crystallographic structure, microstructure, and bonding characteristics) for optimal performance in a given application

Policies**

This class will be taught in-person.

- Class attendance is strongly encouraged. The knowledge gained through the material presented during lecture is critical for success in this class.
- Cell phones are to be turned off or silenced when in class.
- Announcements and assignments will be posted on Canvas and/or sent out to the class via email
- Documented excuse: you must provide a note from the Dean of Students confirming approved Institute activities (section IV.B.3 of the Student Rules and Regulations). Please provide name, email, and phone number.

**Details regarding class layout and schedule are subject to change based on instructor discretion.

Homework

Homework will be graded for completion. While group discussion is encouraged on homework, individuals are expected to submit their own version of the homework assignment. Authorized aid on homework assignments includes discussing the interpretation of the problems, sharing ideas or approaches for solving the problems, and explaining the concepts involved in the problems. Any other aid would be unauthorized and considered a violation of the academic integrity policy. ***For homework that was worked on in groups, all written answers must be written independently and NOT duplicated—duplicated written answers will be considered in violation of the Academic Honor Code.*** All cases of academic misconduct will be submitted to Office of Student Integrity.

Other notes regarding homework:

- Homework is due **on Canvas at the time specified on the assignment.**
- Late grading for homework: Late homework assignments will be accepted up to 24 hours after the due date. **All late assignments will receive a 50% reduction.**

Exams

Exams will be given in-person, in class.

If you miss an exam without either a certified medical excuse or prior instructor approval, you will earn zero credit for that exam. Tests missed with certified medical excuses or prior instructor approval will be dealt with on an individual basis.

Other notes regarding exams:

- Calculators are allowed on all exams
- No makeup exams unless there is an extreme and exceptional situation (must be documented)
- If you require accommodations through ADAPTS, please notify Dr. McDowell ASAP
- Check for final exam period conflicts

Final Report/Project

This class will feature a final report/project that will involve applying concepts learned throughout the semester to materials and systems of interest to you. More information and details will be provided later in the course.

Academic Honor Code

Academic misconduct is any act that does or could improperly distort student grades or other student academic records. Students suspected of academic misconduct will be dealt with according to the policies within the Georgia Tech academic honor code (<http://honor.gatech.edu/content/2/the-honor-code>).

Honor code violations include but need not be limited to the following:

- Possessing, using, or exchanging improperly acquired written or verbal information in the preparation of any essay, laboratory report, examination, or other assignment included in an academic course
- Substitution for, or unauthorized collaboration with, a student in the commission of academic requirements
- **Submission of material that is wholly or substantially identical to that created or published by another person (plagiarism)**
- False claims of performance or work that has been submitted
- Alteration or insertion of any academic grade or rating so as to obtain unearned academic credit
- Deliberate falsification of a written or verbal statement of fact to a member of the faculty so as to obtain unearned academic credit
- Forgery, alteration, or misuse of any Institute document relating to the academic status of the student.

Student-Faculty Expectations

At Georgia Tech we believe that it is important to continually strive for an atmosphere of mutual respect, acknowledgement, and responsibility between faculty members and the student body. In the end, simple respect for knowledge, hard work, and cordial interactions will help build the environment we seek. I encourage you to remain committed to the ideals of Georgia Tech while in this class.

Mental Health and Wellness

As a student you may experience a range of issues that can cause barriers to learning, such as strained relationships, increased anxiety, alcohol/drug problems, depression, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may lead to diminished academic performance or reduce a student's ability to participate in daily activities. GT offers services to assist you with addressing these and other concerns you may be experiencing. If you or someone you know is experiencing any of the issues noted above, consider utilizing the confidential mental health services available on campus. I encourage you to the Center for Mental Health Care & Resources (<https://mentalhealth.gatech.edu/>, 404-894-2575) for support. An on-campus counselor or after-hours services are available to assist you.

Students with Disabilities

The Office of Disability Services serves Georgia Tech students with documented qualifying disabilities and operates under the guidelines of Section 504 of the Rehabilitation Act of 1973 and the Americans with Disabilities Act and its amendments (ADAAA). In accordance with Georgia Tech Policy, "Reasonable accommodations are provided to **self-identified students** with disabilities who meet the academic and technical standards requisite to admission or participation in the program of study. Consideration may be given to the substitution or modification of certain course requirements as long as such changes do not detract from the quality of the educational experience and the changes remain within the accreditation criteria for the degree program." More information can be found here: <https://disabilityservices.gatech.edu/>. Self-identified students with disability should speak with Dr. McDowell during the first week of classes, so that suitable arrangements can be organized.