

Mechanical Behavior of Materials

EMA 4223 Section 0593

Class Periods: Tuesdays, Periods 2-3 (8:30 – 10:25 AM) / Thursdays, Period 3 (9:35 – 10:25 AM)

Location: NZH 112 (Tuesdays), TUR 2319 (Thursdays)

Academic Term: Spring 2025

Instructor:

Ravit Silverstein, Ph.D. (She/ Her)

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Office Hours: TBA

Teaching Assistant/Peer Mentor/Supervised Teaching Student:

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Course Description

This course will discuss the mechanical properties of a wide range of materials from both macroscopic and microscopic viewpoints. Beginning with an overview of elasticity and tensors, the course will describe the deformation and fracture behavior of metals, ceramics and polymers. Dislocation theory, strengthening & toughening mechanisms and rate-dependent deformation will also be discussed.

Course Pre-Requisites / Co-Requisites

Pre-requisite: EGM 3520

Course Objectives

- To gain an appreciation for how mechanical testing at the macro-, micro-, and nanoscale is performed.
- To develop knowledge of elasticity and tensors with applications to crystallographically resolved materials properties.
- To learn the theory of irreversible deformation (plasticity), including dislocations, twinning, strengthening and deformation properties of crystalline materials.
- To understand the effects of sample size on dislocation content and dislocation-free nanomaterials and how these factors contribute to grain boundary, solute (dispersion), and precipitation hardening.
- To learn the basis of fracture and fatigue of materials at the intersection between mechanics and materials science.
- To understand the theory of rate-dependent and high temperature deformation of materials.
- To develop a materials engineering toolbox based on mechanical properties and optimal materials application. The concept of materials properties and deformation mechanisms maps will guide students' physical intuition.

Relation to Program Outcomes (ABET):

The table below is an example. Please consult with your department's ABET coordinator when filling this out.

Outcome	Coverage*
1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	Medium
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	High
3. An ability to communicate effectively with a range of audiences	
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	Medium
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies	Medium

*Coverage is given as high, medium, or low. An empty box indicates that this outcome is not covered or assessed in the course.

Required Textbooks and Software

- *"Materials Science and Engineering: An Introduction"*, by Callister and Rethwisch. 10th edition, ISBN 9781118324578. **Note: you will need WileyPLUS access.**
- *"Mechanical Behavior of Materials"* (2nd edition), by Mark Meyers and Krishnan Chawla Cambridge University Press, 2009

Recommended Materials

In case you are looking to satiate your thirst for additional material or simply for a different perspective from the lecture and the required textbooks:

- *Crystals, Defects and Microstructures: Modeling Across Scales*, R. Phillips, 2001, Cambridge
- *The New Science of Strong Materials, or why you don't fall through the floor*, J.E. Gordon
- *Mechanical Behavior of Materials*, Thomas H. Courtney, 2nd edition, Waveland Press.
- *Deformation and Fracture of Engineering Materials*, Richard W. Hertzberg, 4th edition, Wiley Press
- *Introduction to Dislocations*, Hull and Bacon, 4th edition, Butterworth Heineman (Available as ebrary online book)
- *Physical Properties of Crystals*, J.F. Nye, Oxford Science Publications

Required Computer

UF student computing requirement: <https://news.it.ufl.edu/education/student-computing-requirements-for-uf/>

Course Schedule (subject to change)

WEEK	TOPIC	READING + ASSIGNMENTS
1	Introduction: <i>Mechanical testing of materials, definitions of stress and strain</i>	CH. 6.1 – 6.2 (reading only)
2	Elastic behavior of materials: <i>Hooke's law, relationship to atomic bonding, time-dependent elastic response</i>	CH. 6.3 – 6.5 (PS1)
3 & 4	Elasticity & Plastic deformation of materials: <i>Plasticity in single crystals, slip systems</i>	CH. 6.6 – 6.11/ CH. 7.1 – 7.4 (PS2)
5 & 6	Crystal Slip and Dislocations: <i>Relationship to crystal slip, dislocation motion under forces</i>	CH. 7.5 – 7.7 (PS3)
7 & 8	Strengthening mechanisms: <i>Dislocation interactions with obstacles: other dislocations, point defects, particles, precipitates, grain boundaries.</i>	CH. 7.8 – 7.13 (PS4)
9 & 10	Materials processing: <i>Controlling microstructure through processing</i>	CH. 11.7 – 11.9
Midterm		
11&12	Fracture mechanisms: <i>Brittle and ductile fracture, theoretical cohesive strength</i>	CH. 8.1 – 8.4
13 & 14	Fracture mechanics and toughness: <i>Stress intensity factor, Griffith fracture criterion, and toughening mechanisms</i>	CH. 8.5 – 8.6 CH. 12.8 – 12.11 / CH. 16.1 – 16.5 (PS5)
15 & 16	Cyclic and high temperature deformation: <i>Fatigue and creep</i>	CH. 8.7 – 8.15 (PS6)
17	Mechanical behavior of polymers: <i>Elastic, viscoelastic, plastic, and fracture behavior in polymers</i>	CH. 15.1 – 15.9
FINAL EXAMINATION		

Attendance Policy, Class Expectations, and Make-Up Policy

Class Format: This course is in-person.

The instructor and UF expect the highest standards of honesty and integrity in the academic performance of its students. Any student caught cheating in this course will receive an F, and the case will be officially reported to UF as academic misconduct. At the same time, we strongly encourage collaborative group interactions. Engineers work best in teams to solve complex problems, so we also encourage you to form teams to study complex topics and collaboratively work on course concepts. It is, however, very important for you to distinguish your collaborative work from your own. We expect your final problem sets to carry your signature of your effort. If you have any doubts about your work, then please speak to the instructor or the TA before submitting problem sets.

Class Attendance: Attendance is expected and all class notes are the responsibility of the student. Must participate in 80% of activities to receive full participation credit. Cell phones are expected to be turned off during class. Participation will be used as a resolution of borderline cases.

Excused absences must be consistent with university policies in the undergraduate catalog (<https://catalog.ufl.edu/ugrad/current/regulations/info/attendance.aspx>) and require appropriate documentation.

Requirements for class attendance and make-up exams, assignments, and other work in this course are consistent with university policies. Click here to read the university attendance policies:
<https://catalog.ufl.edu/UGRD/academic-regulations/attendance-policies/>

Evaluation of Grades

Assignment	Total Points	Percentage of Final Grade
Homework Sets (6)	100 each	20%
Midterm Exam	100	35%
Final Exam	100	40%
Participation	80	5%
		100%

Grading Policy

The following is given as an example only.

Percent	Grade	Grade Points
93.4 - 100	A	4.00
90.0 - 93.3	A-	3.67
86.7 - 89.9	B+	3.33
83.4 - 86.6	B	3.00
80.0 - 83.3	B-	2.67
76.7 - 79.9	C+	2.33
73.4 - 76.6	C	2.00
70.0 - 73.3	C-	1.67
66.7 - 69.9	D+	1.33
63.4 - 66.6	D	1.00
60.0 - 63.3	D-	0.67
0 - 59.9	E	0.00

More information on UF grading policy may be found at:
<https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx>

Students Requiring Accommodations

Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the disability Resource Center by visiting <https://disability.ufl.edu/students/get-started/>. It is important for students to share their accommodation letter with their instructor and discuss their access needs, as early as possible in the semester.

Course Evaluation

Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at <https://gatorevals.aa.ufl.edu/students/>. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via <https://ufl.bluer.com/ufl/>. Summaries of course evaluation results are available to students at <https://gatorevals.aa.ufl.edu/public-results/>.

In-Class Recording

Mechanical Behavior of Materials, EMA 4223
Prof. R.S. Silverstein Spring 2025

Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A “class lecture” is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session.

Publication without permission of the instructor is prohibited. To “publish” means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.

University Honesty Policy

UF students are bound by The Honor Pledge which states, “We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: “On my honor, I have neither given nor received unauthorized aid in doing this assignment.” The Honor Code (<https://sccr.dso.ufl.edu/process/student-conduct-code/>) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Commitment to a Safe and Inclusive Learning Environment

The Herbert Wertheim College of Engineering values varied perspectives and lived experiences within our community and is committed to supporting the University’s core values, including the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of race, creed, color, religion, age, disability, sex, sexual orientation, gender identity and expression, marital status, national origin, political opinions or affiliations, genetic information, and veteran status.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

- Your academic advisor or Undergraduate Coordinator
- HWC OE Human Resources, 352-392-0904, student-support-hr@eng.ufl.edu
- Pam Dickrell, Associate Dean of Student Affairs, 352-392-2177, pld@ufl.edu
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, nishida@eng.ufl.edu

Software Use

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as

appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

Student Privacy

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: <https://registrar.ufl.edu/ferpa.html>

Campus Resources:

Health and Wellness

U Matter, We Care:

Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact umatter@ufl.edu so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

Counseling and Wellness Center: <https://counseling.ufl.edu>, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Discrimination, Harassment, Assault, or Violence

If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the **Office of Title IX Compliance**, located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, title-ix@ufl.edu

Sexual Assault Recovery Services (SARS)

Student Health Care Center, 392-1161.

University Police Department at 392-1111 (or 9-1-1 for emergencies), or <http://www.police.ufl.edu/>.

Academic Resources

E-learning technical support, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu. <https://elearning.ufl.edu/>.

Career Connections Center, Reitz Union, 392-1601. Career assistance and counseling; <https://career.ufl.edu>.

Library Support, <http://cms.uflib.ufl.edu/ask>. Various ways to receive assistance with respect to using the libraries or finding resources.

Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring. <https://teachingcenter.ufl.edu/>.

Writing Studio, 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers. <https://writing.ufl.edu/writing-studio/>.

Student Complaints Campus: <https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/>; <https://care.dso.ufl.edu>.

On-Line Students Complaints: <https://distance.ufl.edu/getting-help/>; <https://distance.ufl.edu/state-authorization-status/#student-complaint>.