

SYRACUSE UNIVERSITY
COLLEGE OF ENGINEERING AND COMPUTER SCIENCE
MECHANICS OF SOLIDS
ECS325

CATALOG DESCRIPTION

Theory of deformation, stress, stress resultants, transformation. Equilibrium. Tension and torsion of bars; flexure and shear of beams; design of shafts and beams. Buckling of columns.

This section of ECS 325 is designated as a CURE (Course-based Undergraduate Research Experience). Students will engage in a semester-long, team-based research inquiry that critically examines the fundamental assumptions underlying classical mechanics of materials. Using AI tools as research instruments, teams will investigate where and why standard theories break down, and communicate their findings through a video presentation suitable for a public audience.

INSTRUCTOR INFORMATION

Dr. Anupam Pandey
243 Link Hall
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Office Hours: MW 9:30-10:30A, by appointment.

TEACHING ASSISTANT INFORMATION

Amit Pandey
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Office – Link 169
Office hours – T 2:00-4:30 PM, W 10:30AM-1:00PM

COURSE MATERIALS

Mechanics of Materials by F.P. Beer, E.R. Johnston, J.T. DeWolf and D.F. Mazurek, McGraw Hill, 8th Edition, 2019. **You don't need to buy the book separately**; The e-book, homework problems and smart book assignments are accessible through the **McGraw Hill connect** platform. The following information guides you through the registration process (through the Orange Inclusive Access). In case you need further assistance reach out to the technical support number is given below.

- IA Connect/Blackboard Ultra Student Registration Instructions: [Video](#)
- *For any technical support using Connect, students contact McGraw Hill's Higher Education Technical Support group by phone, chat or email:*
- **Phone: 1-800-331-5094**; Sunday: 12 PM to 1 AM EST, Monday - Thursday: 8 AM to 1 AM EST, Friday: 8 AM to 9 PM EST, Saturday: 10 AM to 8 PM EST
- **Live chat/email:** <https://mhedu.force.com/CXG/s/ContactUs>

PREREQUISITES BY TOPIC

To succeed in this course, students must have successfully completed the following courses (or their equivalents):

Engineering Statics (ECS221), Calculus I (MAT295), & Calculus II (MAT296)

ACADEMIC EXCELLENCE WORKSHOPS

Please consider enrolling in the associated AEW Session **ECS 200 M030 and M031 - AEW for Mechanics of Solids**. You can register via MySlice. For further information on AEW, reach out to aewreg@syr.edu.

COURSE OVERVIEW AND CURE PHILOSOPHY

Classical mechanics of materials rests on a set of simplifying assumptions: materials are linear-elastic, isotropic, and homogeneous; deformations are small; cross-sections remain plane; and stress distributions are uniform far from load application points. These assumptions are powerful — they make analysis tractable — but they also have boundaries. Real materials are anisotropic, nonlinear, and heterogeneous. Real structures experience large deformations, dynamic loads, and complex geometries.

In this course, you will learn the classical theory and systematically question it. Working in teams of 4–5, you will select a foundational assumption, use AI tools to probe its limits, and produce a scholarly video that communicates your findings to an audience of engineers, students, and the public.

This is genuine research. The outcomes of your investigation are not predetermined. You may discover surprising edge cases, generate novel visualizations of failure modes, or identify conditions where textbook formulas diverge significantly from more realistic models. Your work has the potential to contribute to engineering education and to be presented or published.

GRADING STRUCTURE

Component	Weight	Category
CURE Research Project (Total)	70%	CURE
Milestone 1: Topic Selection & Literature Review	8%	CURE
Milestone 2: Research Plan & AI Methodology	8%	CURE
Milestone 3: Preliminary Findings & Peer Review	10%	CURE
Milestone 4: Draft Video & Peer Feedback	10%	CURE
Final Video Presentation	20%	CURE
Research Portfolio (AI logs, reflections, annotated work)	9%	CURE
Individual Contribution & Reflection	5%	CURE
Homework (McGraw Hill Connect)	20%	Non-CURE
Final Exam	10%	Non-CURE

LETTER GRADE CONVERSION

90 — 100 : A
80 — 90 : B
70 — 80 : C
60 — 70 : D
less than 60: F

CURE RESEARCH PROJECT: DETAILED DESCRIPTION

The Central Question - *Under what conditions do the foundational assumptions of classical mechanics of materials break down, and what are the consequences for engineering analysis and design?*

Research Topics

Each team will select one topic from the list below. No more than two teams may work on the same topic; selections are first-come, first-served.

1. Hooke's Law and Linearity — Where does the linear stress-strain assumption fail? Investigate hyperelastic materials (rubber, biological tissue), plasticity, and viscoelasticity. How large are the errors when applying linear theory to nonlinear materials?
2. Small Deformation Assumption — Classical theory assumes deformations are infinitesimally small. Explore problems (e.g., thin cantilevers, buckling, flexible electronics) where large-deformation (geometric nonlinearity) effects become significant.
3. Isotropy and Homogeneity — Real materials (wood, composites, bone, 3D-printed parts) are often anisotropic and heterogeneous. Investigate how classical formulas for bending, torsion, or stress concentration change when material symmetry is broken.
4. Plane Sections Remain Plane (Euler-Bernoulli Beam Theory) — This assumption underlies all of beam bending theory. Probe situations (short deep beams, sandwich structures, beams with cutouts) where it fails and Timoshenko or higher-order theories are needed.
5. Saint-Venant's Principle — "Far from the point of load application, the stress distribution is independent of the actual load distribution." When does this principle fail? Investigate thin-walled structures, stress concentrations, and composite laminates.
6. Euler Buckling and Ideal Columns — Real columns have initial imperfections, eccentric loads, residual stresses, and inelastic behavior. How sensitive is the Euler formula to deviations from its assumptions?
7. Uniform Shear Stress Distribution — The shear formula (VQ/It) assumes thin-walled sections and specific distributions. Explore where this breaks down: thick sections, open vs. closed profiles, and warping effects.
8. Static and Quasi-Static Loading — Classical theory assumes loads are applied slowly. Investigate how dynamic loading, impact, fatigue, and strain-rate sensitivity change the picture.

How AI Is Used in This Course

AI tools (such as Claude, ChatGPT, or similar) serve as research instruments in this course, not as shortcuts. Specifically, teams will:

- Use AI to derive or verify analytical solutions under modified assumptions (e.g., "re-derive the bending stress formula without assuming small deformations")
- Use AI to generate computational examples and numerical comparisons (e.g., Python/MATLAB scripts that compare linear vs. nonlinear predictions)
- Use AI to explore edge cases and "what if" scenarios systematically
- Critically evaluate AI outputs against textbook solutions, published literature, and physical reasoning
- Document all AI interactions in a research log, including prompts, outputs, errors, and corrections

Critical rule: AI is a tool for inquiry, not a substitute for understanding. Every AI-generated result must be validated, interpreted, and contextualized by the team. Your research portfolio must demonstrate that you understand why the AI produced what it did, not just what it produced.

CURE MILESTONE SCHEDULE

Week 1–2 (Jan 12–21): Introduction to CURE Overview of project; discussion of assumptions in mechanics of materials

Week 3 (Jan 26–28): Team Formation Teams of 4–5 formed; topic preferences submitted

Week 4 (Feb 2–4): **MILESTONE 1 DUE (Feb 4)** Topic Selection & Literature Review: 2–3 page summary of chosen assumption, its role in classical theory, and 5+ sources on known limitations

Week 5–6 (Feb 9–18): Research Design Phase Develop research questions, plan AI-based investigations

Week 7 (Feb 23–25): **MILESTONE 2 DUE (Feb 25)** Research Plan & AI Methodology: Detailed plan with research questions, AI workflows, comparisons, and division of labor

Week 8–9 (Mar 2–4): Active Investigation Teams conduct AI-assisted research; collect and organize findings

Week 10 (Mar 16–18): **MILESTONE 3 DUE (Mar 18)** Preliminary Findings & Peer Review: Each team presents initial results to another team for structured peer feedback

Week 11–12 (Mar 23–Apr 1): Deepening Analysis Refine findings; iterate on AI investigations; begin video planning

Week 13 (Apr 6–8): **MILESTONE 4 DUE** (Apr 8) Draft Video & Peer Feedback: 3–5 min rough cut; peer teams provide feedback

Week 14–15 (Apr 13–22): Final Production Revise video; compile research portfolio; write individual reflections

Week 16 (Apr 27): **FINAL VIDEO & PORTFOLIO DUE**

CURE DELIVERABLES IN DETAIL

Milestone 1: Topic Selection & Literature Review (8%)

- Select a topic from the approved list
- Provide a 2–3 page written summary including: the assumption and its role in classical theory, at least 5 scholarly or technical sources that discuss its limitations, and a preliminary statement of why this matters for engineering practice
- Graded on: depth of understanding, quality of sources, clarity of writing

Milestone 2: Research Plan & AI Methodology (8%)

- Formulate 2–3 specific, testable research questions (e.g., "At what beam depth-to-span ratio does the Euler-Bernoulli prediction for maximum deflection deviate by more than 10% from a Timoshenko model?")
- Describe your planned AI workflow: what tools you will use, what types of prompts, what kinds of outputs you expect
- Include a task allocation plan showing each team member's responsibilities
- Graded on: specificity and feasibility of questions, thoughtfulness of methodology, equitable distribution of work

Milestone 3: Preliminary Findings & Peer Review (10%)

- Present preliminary results in a 10-minute in-class presentation to your assigned peer team
- Include at least one concrete example where the assumption was tested (with AI-generated calculations, code, or visualizations)
- Receive and provide structured peer feedback using the course rubric
- Graded on: quality of preliminary results, engagement with peer review process (both giving and receiving), evidence of critical evaluation of AI outputs

Milestone 4: Draft Video & Peer Feedback (10%)

- Submit a 3–5 minute rough cut of your video
- Peer teams review using the video rubric and provide written feedback

- Graded on: clarity of narrative structure, quality of technical content in draft form, quality of feedback provided to peers

Final Video Presentation (20%)

Produce an 8–12 minute video designed for a public audience (think YouTube educational content) that:

- Clearly explains the assumption being investigated and why it matters
- Walks through the research process, including how AI tools were used
- Presents key findings with visualizations, examples, and/or animations
- Discusses implications for engineering practice and education
- Is engaging, well-produced, and accessible to an audience of engineering students

Video Rubric:

Criterion	Excellent (A)	Good (B)	Adequate (C)	Needs Work (D/F)
Technical Depth	Thorough investigation with multiple examples; clear quantitative comparisons	Solid investigation with good examples	Surface-level treatment; limited examples	Superficial or inaccurate
Critical Use of AI	AI used creatively as a research tool; outputs rigorously validated and critiqued	Good use of AI with adequate validation	AI used but limited critical evaluation	AI outputs accepted uncritically or AI barely used
Communication	Compelling narrative; excellent visuals; accessible and engaging	Clear and well-organized	Understandable but dry or disorganized	Confusing or poorly produced
Scholarly Contribution	Findings offer genuine insight; could inform teaching or further research	Useful findings with some novel aspects	Findings are correct but largely confirmatory	Little scholarly value
Teamwork & Process	Clear evidence of equitable collaboration and iterative improvement	Good collaboration with some iteration	Uneven collaboration	Minimal evidence of teamwork

Research Portfolio (9%)

A compiled document (PDF) that includes:

- A log of all significant AI interactions: prompts used, outputs received, your evaluation of each output (correct? partially correct? misleading? why?)
- Annotated code, calculations, or derivations produced during the project
- A narrative (1–2 pages) describing how your research evolved over the semester — what you expected, what surprised you, and how you iterated
- Graded on: thoroughness of documentation, depth of critical evaluation, evidence of intellectual growth

Individual Contribution & Reflection (5%)

Each student submits individually:

- A 1-page reflection on what you learned about the research process, your team's dynamics, and how your understanding of mechanics of materials changed
- A confidential peer evaluation of team members' contributions
- Graded on: depth of reflection and honest self-assessment

SCHEDULE

DATE	CLASS	SECTIONS	HW PROBLEMS	HW DUE DATE	SB DUE DATE
1/12M	Lecture 1	1.1, 1.2	1.4, 1.9	HW 1 - 1/21 W	Chapter 1 1/22Th
1/14W	Lecture 2	1.2-1.5	1.23, 1.32, 1.37		
1/19M	Martin Luther King Jr. Day				
1/21W	Lecture 3	1.5, 2.1, 2.2	2.6, 2.11, 2.23	HW 2 - 1/30 F	Chapter 2 1/29Th
1/26M	Lecture 4	2.3-2.7	2.26, 2.35, 2.44		
1/28W	Lecture 5	2.7, 3.1, 3.2	2.66, 2.68, 2.70	HW 3 - 2/6 F	Chapter 3 2/5Th
2/2M	Lecture 6	3.3, 3.4	3.6, 3.25, 3.35, 3.59, 3.65, 3.74		
2/4W	Lecture 7	4.1, 4.3	4.2, 4.10, 4.19	HW 4 - 2/13 F	Chapter 4 2/12Th
2/9M	Lecture 8	4.3, 4.4	4.33, 4.99		
2/11W	Lecture 9	4.7	4.111		
2/16M	Lecture 10	4.7, 5.1	5.10, 5.15, 5.45	HW 5 - 2/27 F	Chapter 5 2/26Th
2/18W	Lecture 11	5.1, Review Problems			
2/23M	Exam 1	Chapter 1-3			
2/25W	Lecture 12	5.2, 5.3	5.53, 5.69, 5.84	HW 6 - 3/6 F	Chapter 6 2/5Th
3/2M	Lecture 13	6.1, 6.3	6.1, 6.5, 6.21		
3/4W	Lecture 14	6.4	6.33, 6.49		
3/9-13	No Classes (Spring Break)				
3/16M	Lecture 15	7.1, 7.2	7.7, 7.11, 7.19	HW 7 - 3/20 F	Chapter 7 2/12Th
3/18W	Lecture 16	7.3, 7.5	7.67, 7.87, 7.103, 7.104		
3/23M	Lecture 17	7.5, Review Problems			
3/25W	Exam 2	Chapter 4-6			
3/30M	Lecture 18	8.1	7.112, 8.3	HW 8 - 4/3 F	Chapter 8 4/9Th
4/1W	Lecture 19	8.2	8.18	HW 9 - 4/10 F	
4/6M	Lecture 20	8.3	8.38, 8.61		
4/8W	Lecture 21	9.1	9.6, 9.7, 9.18	HW 10 - 4/17 F	Chapter 9 4/16Th
4/13M	Lecture 22	9.2	9.24, 9.29		
4/15W	Lecture 23	9.4	9.78, 9.82		
4/20M	Lecture 24	10.1	10.2, 10.6, 10.19, 10.26	HW 11 - 4/24 F	Chapter 10 4/23Th
4/22W	Lecture 25	10.2	10.29, 10.36		
4/27M	Lecture 26	Review Problems			

Home works and smart book assignments are due at 11:59PM on the given dates.

Lecture 8, 15, and 16 will be over zoom. The zoom link will be posted on Blackboard.

Final Exam: 4/30/2026 (Thursday) 12:45 PM – 2:45 PM Life Science Building 105

COURSE LEARNING OBJECTIVES

At the completion of the course, each student should be able to:

- A. learn the fundamentals of deformation and stress in solid bodies (*ABET Mechanical Engineering Program Outcomes a, e, l*)
 - 1. understand the physical and geometrical meaning of normal stress, normal strain and volume strain in axially loaded members
 - 2. understand the physical and geometrical meaning of shear and bearing stress and shear strain
 - 3. understand the physical and geometrical meaning of torsional shear stress and torsional deformation in bars
 - 4. understand and use the relationships between loads, shear forces and bending moments in beams
 - 5. understand the physical and geometrical meaning of bending stress and curvature in beams
 - 6. understand the physical and geometrical meaning of shear stress in beams
 - 7. calculate plane stress and strain components in arbitrarily oriented elements; calculate principal stresses and strains and principal axes
 - 8. understand the physical and geometrical meaning of stress and strain in thin walled cylindrical and spherical pressure vessels

- B. obtain an understanding of the mechanical properties of various materials (*ABET Mechanical Engineering Program Outcomes a, e*)
 - 1. understand the basic features of the stress-strain curve in tension and shear for a variety of materials
 - 2. understand the effects of time and temperature on mechanical behavior
 - 3. understand the physical meaning of the elastic and shear modulus, Poisson's ratio
 - 4. understand the concepts of material homogeneity, isotropy and anisotropy

- C. acquire the ability to predict stresses, deformations and failure in specific structural elements subject to a variety of mechanical and thermal loadings (*ABET Mechanical Engineering Program Outcomes a, e, l*)
 - 1. solve statically determinate and indeterminate problems involving uniform and nonuniform axial and torsionally loaded members
 - 2. solve for bending and shear stresses in statically determinate and indeterminate beams with symmetrical cross section and predict deflections of the beam axis
 - 3. solve cylindrical and spherical pressure vessel problems
 - 4. analyze beams, bars and vessels under combined loading
 - 5. use energy methods to solve statically determinate and statically indeterminate truss and beam problems
 - 6. predict buckling of columns under a variety of support conditions

Syllabus Notes

STUDENTS IN QUARANTINE OR ISOLATION

Students who enter quarantine (exposure to a COVID-positive person) or isolation (confirmed COVID infection) will not be able to attend in-person class sessions. Instructors will receive a notification that the student is unable to attend class. Students in quarantine or isolation who have no symptoms or only mild symptoms may continue to participate in classes remotely if that option exists. If a student is sick and unable to participate in class at all, faculty will be notified by the office of the Dean of Students.

Faculty teaching classes that are fully in-person should be prepared to accommodate students who enter into quarantine or isolation, just as they would accommodate any student who falls ill for an extended period of time.

STUDENT MENTAL HEALTH

Mental health and overall well-being are significant predictors of academic success. As such it is essential that during your college experience you develop the skills and resources effectively to navigate stress, anxiety, depression, and other mental health concerns. Please familiarize yourself with the range of resources the Barnes Center provides (<https://ese.syr.edu/bewell/>) and seek out support for mental health concerns as needed. Counseling services are available 24/7, 365 days, at 315-443-8000, and I encourage you to explore the resources available through the Wellness Leadership Institute, <https://ese.syr.edu/bewell/wellness-leadership-institute/>

ATTENDANCE

Attendance policies during the COVID-19 pandemic will be strictly enforced unless there is a valid excuse. Our institutional policy is that attendance is expected in all courses at Syracuse University. This applies both to in-person and online class meetings. However, the university's Stay Safe Pledge requires students to stay away from in-person classes when they feel unwell. It is in no one's best interest to incentivize a sick student to attend class. Therefore, we will be flexible in accommodating students who cannot attend class due to illness provided prior arrangements have been made.

USE OF CLASS MATERIALS AND RECORDINGS

Original class materials (handouts, assignments, tests, etc.) and recordings of class sessions are the intellectual property of the course instructor. You may download these materials for your use in this class. However, you may not provide these materials to other parties (e.g., web sites, social media, other students) without permission. Doing so is a violation of intellectual property law and of the student code of conduct.

ACADEMIC INTEGRITY

Syracuse University's [Academic Integrity Policy](#) reflects the high value that we, as a university community, place on honesty in academic work. The policy holds students accountable for the

integrity of all work they submit and for upholding course-specific, as well as university-wide, academic integrity expectations. The policy governs citation and use of sources, the integrity of work submitted in exams and assignments, and truthfulness in all academic matters, including course attendance and participation. The policy also prohibits students from: 1) submitting the same work in more than one class without receiving advance written authorization from both instructors and, 2) using websites that charge fees or require uploading of course materials to obtain exam solutions or assignments completed by others and present the work as their own. Under the policy, instructors who seek to penalize a student for a suspected violation must first report the violation to the Center for Learning and Student Success (CLASS). Students may not drop or withdraw from courses in which they face a suspected violation. Instructors must wait to assign a final course grade until a suspected violation is reviewed and upheld or overturned. Upholding Academic Integrity includes abiding by instructors' individual course expectations, which may include the protection of their intellectual property. Students should not upload, distribute, or otherwise share instructors' course materials without permission. Students found in violation of the policy are subject to grade sanctions determined by the course instructor and non-grade sanctions determined by the School or College where the course is offered, as described in the Violation and Sanction Classification Rubric. Students are required to read an online summary of the University's academic integrity expectations and provide an electronic signature agreeing to abide by them twice a year during pre-term check-in on MySlice.

Based on the specific learning outcomes and assignments in this course, artificial intelligence is permitted on the following: Homework. See each assignment, quiz, or exam instructions for more information about what artificial intelligence tools are permitted and to what extent, as well as citation requirements. If no instructions are provided for a specific assignment, then no use of any artificial intelligence tool is permitted. Any AI use beyond that which is detailed in course assignments is explicitly prohibited except when documented permission is granted.

The Violation and Sanction Classification Rubric establishes recommended guidelines for the determination of grade penalties by faculty and instructors, while also giving them discretion to select the grade penalty they believe most suitable, including course failure, regardless of violation level. Any established violation in this course may result in course failure regardless of violation level.

DISABILITY STATEMENT

Syracuse University values diversity and inclusion; we are committed to a climate of mutual respect and full participation. There may be aspects of the instruction or design of this course that result in barriers to your inclusion and full participation in this course. I invite any student to contact me to discuss strategies and/or accommodations (academic adjustments) that may be essential to your success and to collaborate with the Center for Disability Resources (CDR) in this process.

If you would like to discuss disability-accommodations or register with CDR, please visit [Center for Disability Resources](#). Please call (315) 443-4498 or email disabilityresources@syr.edu for more detailed information.

The CDR is responsible for coordinating disability-related academic accommodations and will work with the student to develop an access plan. Since academic accommodations may require

early planning and generally are not provided retroactively, please contact CDR as soon as possible to begin this process.

RELIGIOUS OBSERVANCES POLICY

Syracuse University recognizes the diversity of faiths represented in the campus community and protects the rights of students, faculty, and staff to observe religious holy days according to their traditions. Under the policy, students are given an opportunity to make up any examination, study, or work requirements that may be missed due to a religious observance, provided they notify their instructors no later than the academic drop deadline. For observances occurring before the drop deadline, notification is required at least two academic days in advance. Students may enter their observances in MySlice under Student Services/Enrollment/My Religious Observances/Add a Notification.

CODE OF PROFESSIONAL CONDUCT IN THE CLASSROOM¹

In preparing our students for careers in engineering, it is essential that we strive for the highest levels of professionalism. Central to that objective is the development of a respectful and professional atmosphere in and around the classroom. It is expected that both students and professors will treat each other with respect and consideration. In order to foster such an environment, the following is expected of all parties:

Communal Responsibilities:

Classroom Preparation: Students and professors must come to class prepared for that day's topic and be ready to engage themselves.

Timeliness: Both students and professors should arrive before the official start of class, such that the professor then begins class on time. It is the responsibility of the professor to then end class on time, thus not causing students to be late for their next class.

Food: Individuals should be discreet in the bringing of food into the classroom, and it is the responsibility of each person to properly dispose of any waste they may create so as not to detract from the development of a professional atmosphere.

Student Responsibilities:

Electronics: Electronics should only be used in support of the classroom experience. Towards this end, the following policies hold:

- **Use of cell phones is not allowed during the class.**
- **The use of computers and ipads in the classroom (other than taking notes) is prohibited under all circumstances. Checking email, surfing the web, chatting on the net, or working on other projects are not acceptable forms of behavior.**

Other Disruptions: Students should not be walking in and out of class to attend to other matters. Nor should they be talking loudly.

¹ This document is adapted from: <http://www.mcgill.ca/desautels/resources/building-admin/code-conduct>.