PURDUE
UNIVERSITY

Course Information

Course number and title: **AAE 54800 – Mechanical Behavior of Aerospace Materials**
CRN: **28952 - AAE 54800 – WNG / 31447 - AAE 54800 – EPE**
Meeting time: Tuesdays and Thursdays, 10:30 am - 11:45 am ET, Seng-Liang Wang Hall 2555
Meeting type: Face-to-Face (lecture) or Asynchronous, Online Format (distance learning)
Course credit hours: **3.000**
A web page for this course will be available through Brightspace
Prerequisites: Basic undergraduate knowledge of strength of materials. No prior knowledge of materials science is required.

Information About the Instructor

Name: **Professor Michael D. Sangid**
Office Location: **ARMS 2027** Phone number: **765-494-4046**
Email: msangid@purdue.edu

Office hours: Office hours will be held immediately after class (Tuesdays and Thursdays: 11:45 am to 12:15 pm ET). Please let me know after class in Wang if you would like to meet and we will either meet in Wang or walk back to my office in ARMS. For distance students, office hours are also available via request. The schedule for office hours may change throughout the semester, in which case an announcement will be made through Brightspace.

Information About the Teaching Assistants

Name: **Sai Harshit Gaddam**; Email: gaddam3@purdue.edu
Name: **Vasudha Kapre**; Email: vkapre@purdue.edu
Saturdays Office hours: 10 – 11 am EST online via MS Teams (link)
Mondays Office hours: 4 – 5 pm EST in person in BHEE 236 and online via MS Teams (link)

Course Description

This course serves as an overview for materials behavior for students without a materials background, including seniors and entry-level graduate students. Materials are at the foundation for all of engineering, as evident by the latest products that we design, to the airplanes that we fly, to the latest smart phones. In fact, breakthroughs with material research are often accompanied by rapid advancements in technology. Thus, it is paramount for all engineers to have an understanding of the structure and behavior of materials.

In this class, we focus on the structure of materials, the microstructure connection to mechanical properties, and ultimately failure mechanisms. Materials play an important role in both design and manufacturing, which will be addressed in the context of components and extreme environments. Of specific interest will be defects within materials, defect formation/evolution, and their role in strengthening mechanisms.

Material anisotropy, micromechanisms, and elasto-plastic properties at the atomic, single-crystal/constituent, and polycrystal/material levels and their use in explaining the deformation and failure characteristics in metals, polymers, and ceramics; failure mechanisms and toughening in composites; structure and behavior of aerospace materials: metal alloys, ceramic-matrix composites, and fiber-reinforced polymer composites. Particular topics will also include: elastic deformation, dislocation mechanics, plastic deformation and strengthening mechanisms, creep, and failure mechanisms; design criteria; special topics. We will attempt to have minimal overlap with AAE 554 ‘Fatigue of Structures and Materials’, therefore we will not cover fracture, fatigue, or stress concentrators.

Learning Outcomes by Modules and Topics

By the end of this course, a student should be able to:

Module 1: Indices Notation	Learning Objective
Examples of Indicial Notation	Develop expanded/contracted expressions for indiciual notation. Apply dot/cross products.
Module 2: Crystallography	
Intro to Crystallography	Classify crystallinity types for materials.
Miller Indices-Direction	Identify crystallographic directions. Interpret families of crystallographic directions.
Miller Indices-Planes	Identify crystallographic planes. Interpret families of crystallographic planes.
Miller Indices-Examples	Evaluate crystallographic directions and planes.
Crystal Terminology	Identify crystallographic symmetries. Classify types of crystals.
BCC	Assess packing structure. Interpret slip system configurations.
FCC and HCP	Assess packing structure. Interpret slip system configurations.
Stereography	Recall orientation interpretation of a crystal.
What is a Crystal?	Summarize the definition of a crystal.
Module 3: Elasticity	
Atomistic Persepctive	Relate elastic behavior to atomic structure.
Anisotropic Elasticity	Interpret elasticity based on indicial notation.
Crystallogrpahic Symmetries in Elasticity	Infer symmetries in elasticity based on crystallography.
Elastic Relationships	Evaluate elasticity based on anisotropic behavior.
Module 4: Stress-Strain and Yielding	
Testing Overview	Relate non-dimensional aspects of specimen geometry on stress-strain curve. Compare characteristics of stress-strain cureves based on material classifications.
Stress-Strain Curves	Dissect the elastic and plastic behavior from stress-strain curve. Define material properties. Determine 3D stress and strain states.
Necking Mechanism	Summarize failure mechanism in ductile material at necking. Illustrate role of hydrostatic stress on void formation.
True Stresses and True Strains	Determine true stress and engineering stress relationships. Determine true strain and engineering strain relationships.
Power Law Strain Hardening	Construct the Ramberg-Osgood relationship. Deduce the strain hardening exponent.
Plane Stress and Plane Strain Definitions	Define plane strain and plane stress assumptions.
Yielding and Max Principal Stress Criteria	Explain the max principal stress yield criterion. Evaluate for the max principal stress yield criterion.
Max Shear (Tresca) Criteria	Explain the Tresca yield criterion. Evaluate for the Trasca yield criterion.
Von Mises Criteria	Explain the von Mises yield criterion. Evaluate for the von Mises yield criterion.
Example Part I	Demonstrate understaning of anisotripic elasticity, crystallography, micromechanics, and indicial notation.

Example Part II	Demonstrate understanding of anisoropic elasticity, crystallography, micromechanics, and indicial notation.
Module 5: Dislocations	
Why are Dislocations Important?	Explain dislocations role in mechanical behavior.
Types of Defects	Classify types of defects.
Point Defects	Classify types of point defects.
Edge and Screw Disclocations	Define edge and screw dislocations. Identify Burgers circuit and Burgers vector. Identify dislocation line and relationship with Burgers vector.
Mixed Dislocations	Evaluate components of dislocations. Infer modality of dislocations.
Volterra Description	Illustrate modality of dislocations.
Elastic Properties of Screw Dislocations	Determine stress fields and energy of screw dislocations.
Energy Contribution of Dislocation Core	Dissect elastic versus core contributions to energy.
Elastic Properties of an Edge Dislocation	Relate stress field to edge dislocation.
Forces on Dislocations	Analyze forces on dislocation from Peach-Koehler eq. Relate forces on dislocation to motion of dislocation.
Example Calculations of Force on Dislocation	Solve for forces on dislocations.
Forces on Parallel Dislocations	Solve for forces between dislocations.
Forces on Dislocation Pile-Ups	Construct forces on a pile-up location.
Motion of Dislocations	Illustrate glide of a dislocation.
Thompson Tetrahedron	Relate slip systms in FCC crystal to geometry.
Glissile vs Sessile-Dislocation Motion	Contrast glissile and sessile mtion Identify and classify dislocation lock fomration.
Climb of Dislocations	Define and illustrate climb of dislocations. Evaluate force components (glide/climb) on dislocations.
Cross Slip of Dislocations	Define and illustrate cross-slip of dislocations.
Formation of Kinks and Jogs	Define and illustrate kinks/jogs in dislocations.
Sources of Dislocations	Classify sources of dislocations. Define and illustrate Frank-Reed Sources.
Orowon Equations of Motion	Relate shear strain and shear strain rate to dislocation motion.
Example of Dislocation Motion-Part I	Evaluate interaction mechanisms between dislocations.
Example of Dislocation Motion-Part II	Evaluate interaction mechanisms between dislocations.
Module 6: Partial Dislocation and Stacking Faults	
Defining a Partial Dislocation in FCC	Define and illustrate a partial dislocation in FCC materials.
Defining Stacking Faults in FCC	Define and illustrate a stacking fault in FCC materials.
Answering Questions Regarding Stacking Faults	-
Connections Between Stacking Faults and Partials	Relate stacking faults and partial dislocations Infer the importance of stacking fault energy in mechanical behavior
Annihilation of Dislocations and Latent Heat	Define annihilation of dislocations. Relate annihilation of dislocations to latent heat of fusion.
Module 7: Crystallographic Slip	
Definition of Slip in Single Crystals	Define slip in single crystals. Relate crystallography to slip system.
Schmid Law	Analyze resolved shear stress on slip systems.
Example of Slip in Single Crystals	Evaluate Schmid factor in single crystals. Identify active slips systems.
Strain from Slip in Single Crystals	Analyze resolved shear strain on slip systems.

Single Crystal Stress Strain Curves	Relate stages of hardening in single crystal stress-strain curve.
Hardening and Number of Active Slip Systems	Deduce number of active slip systems and relationship to hardening. Distinguish plastic anisotropy related to loading direction.
Shear Strain Rates from Slip	Relate dislocation motion to continuum mechanics, velocity gradient.
Cryastal Rotation During Slip	Justify the interrelationship between slip and crystal rotation.
Slip in Polycrystals	Distinguish microplasticity versus global yielding.
Bicrystals	Evaluate compatibility and equilibrium across bicrystal
Compatibility Conditions	Relate compatability conditions to von Mises yield criterion and hardening
Theories for Polycrystalline Deformation	Define Sachs, Taylor, Bishop-Hill theories. Construct and evaluate assumptions for each deformation theory. Compare deformation theories.
Heterogeneous Deformation	Relate deformation theories to experimental evidence in real materials.
Geometrically Necessary Dislocations	Define geometrically necessary and statistically stored dilocations. Interpret and illustrate geiometrically necessary dislocations.
Module 8: Twinning and Shape Memory Effect	
Definition of Twins	Define twinning.
Types of Twinning	Classify types of twinning. Rleate twinning to low energy boundaries. Identify character of annealing twings.
Directionality of Twinning	Contrast twinning and slip. Identify directionality of twinning.
Atomistic View of Twinning	Interpret atomistic view of twin formation. Relate twin formation with stacking fault energy.
Example of Shape Memory Effect	Illustrate the shape memory effect
Definition of Shape Memory	Classify shape memory and superlastic effect Relate shape memory effect to phase transformation
Stress Strain Considerations from Shape Memory	Identify reversable phase transformation to stress-strain behavior Identify thermo mechanical deformation of shape memory alloys
Module 9: Strengthening Mechanisms	
Intro to Strengthening Mechanisms	Impact strengthening mechanisms in engineering alloys
Definition of Solid Solution Strengthening	Define solid solution hardening
Force Mechanism for Solid Solution Strengthening	Evaluate the forces exerted on dislocations from solutes
Strain Rate Effects and Dynamic Strain Aging	Distinguish the strain rate influence from Cottrell atmospheres Define dynamic strain aging Relate strain rate to temperature via the Zener-Hollomon parameter
Precipitation Strengthening	Construct the formation of precipitates in crystals
Nondeformable Particles/Percipitates	Classify deformable versus non-deformable particles Illustrate the mechanism for non-deformable precipitates Evaluate strengthening mechanism for non-deformable precipitates based on size
Shearable Particles/Precipitates	Define penetrable/soft precipitates Illustrate the mechanism for deformable precipitates Evaluate strengthening mechanism for deformable precipitates based on size
Coherent Particles and Example of Superalloys	Define ordered, coherent precipitates

	Illustrate anti-phase boundary energy
Incoherent Particles	Illustrate lattice strain for incoherent particles
Work Hardening Mechanism and Stages	Evaluate the Taylor equation for work hardening Classify stages of work hardening
Work Hardening Rates	Illustrate hardening curves and mechanisms in polycrystalline materials Evaluate hardening based on Zener-Holloman relationships Distinguish strain rate effects on strength due to sources/sinks of defects.
Grain Boundary Strengthening Mechanisms	Relate grain boundary strengthening to interaction and pile-up of dislocations
Hall-Petch Equation	Formulate the Hall-Petch equation from pile-up models
Slip Transfer Across Grain Boundaries	Analyze slip transfer based on LRB Criteria
Types of Grain Boundaries	Classify types of grain boundaries Relate grain boundary energy to atomic structure Relate grain boundary energy to mechanical properties
Module 10: Creep	
Intro to Creep Relationships	Identify variables influencing creep Classify stages of creep Analyze Arrhenius laws governing steady state creep rates
Stress Relaxation from Creep	Formulate stress relaxation rate from fixed displacements
Larson Miller Parameter	Formulate Larsen-Miller Parameter Construct, Illustrate, Analyze, Interpret Larsen-Miller Curve Identify change in mechanism from Larsen-Miller Curve
Case Study of Creep in Ice	Evaluate steady state creep response in glaciers
Overview of Creep Mechanism	Classify, define, and illustrate mechanisms of creep
Ashby Map	Construct and interpret creep mechanism map Identify microstructure effects on diffusional mechanism – Coble/N-H Creep
Example for Ashby Map	Develop creep mechanism regimes in Ashby map Identify steady state creep responses based on active mechanism
Module 11: Two Bar Problems and Residual Stress	
Application of a Two Bar Problem	Construct and interpret creep mechanism map Identify microstructure effects on diffusional mechanisms – Coble/ N-H Creep
Two Bar Example	Solve two bar problems
Atomistic Origins of Residual Stresses	Elaborate on atomistic rational and origins of residual stress Discuss paradigm of elastic response of residual stress to plasticity
Example of Residual Stresses	Determine residual stress in structures
Module 12: Ceramics, Probability of Failure, and Statistical Variations	
Statistical Failure of Ceramics Background	Discuss flaw mediated failure in ceramics and brittle materials
Weibull Distributions	Formulate Weibull probabilities Interpret probability of failure plots
Example of Weibull applied to loading types	Solve for probability of failure/survival from Weibull statistics Relate highly stressed volume to probability of failure
Construction of Weibull Plot	Construct and evaluate Weibull plot
Statistical Variation in Mechanical Properties	Recall statistical definitions Relate variability in properties to pedigree, material variability, and structure sensitivity

Fatigue Variability	Relate variability in fatigue performance to variability and rare events in microstructure
Probabilistic Failure Theories	Recall reliability analysis based on probabilistics
Module 13: Polymer Structure, Deformation, Fracture, and ViscoElasticity	
Molecular Structure	Recall the variables effecting molecular shape Evaluate number-average and weight-average molecular weights Distinguish the mer and polymer units
Classification of Polymers	Categorize the type of polymers
Polymer Crystallization	Classify the degree of crystallinity Evaluate the degree of crystallinity based on specific volume and change in enthalpy during processing Define glass transition temperature
Mechanical Behavior of Polymers	Classify mechanical properties of polymers Illustrate deformation mechanisms in polymers
Stiffening and Strengthening Mechanisms	Categorize stiffening and strengthening mechanisms in polymers Interpret polymer structure with glass transition temperature
Viscoelasticity Definition	Define and interpret viscoelasticity in polymers Relate viscoelasticity to polymer structure
Rheological Models of Viscoelasticity	Evaluate Maxwell and Voigt rheological models Compare constant load vs fixed displacement contraints
More Intricate Rheological Models	Recall clamps and more complex rheological models
Biomedical Examples	-
Variables Effecting Viscoelasticity	Relate temperature, strain rate, and polymer structure to degree of viscoelasticity
Example of Fitting a Rheological Model	-
Deformation of Polymers	Define shear banding in polymers
Fracture of Polymers	Classify fracture behaviors in polymers
Crazing in Polymers	Define and illustrate mechanisms of craze yielding in polymers
Craze Yielding Criterion	Evaluate craze yield surface Develop role of hydrostatic stress on craze formation Contrast crazing versus shear banding
Tear Strength	Identify Griffith fracture criteria
Environmental Degradation	Recall environmental degradation mechanisms
Case Study of Bone Cement	Relate porosity in polymer structures to mechanical behavior
Case Study of Self Healing Polymers	Recall active research in polymer behavior
Module 14: Composites	
Classification of Composites	Classify types and structures of composites
Composite Processing	Illustrate composite processing methodology
Stiffness of Laminate Composites	Formulate anisotropic stiffness of laminates
Stiffness of Fiber Reinforced Polymers	Formulate anisotropic stiffness of fiber reinforced composites
Strength of Fiber Reinforced Polymers – Case I	Formulate strength of composites with high ductility fibers
Strength of Fiber Reinforced Polymers – Case II	Formulate strength of composites with low ductility fibers
Further examination of load transfer to fibers	Analyze load distribution between fiber and matrix
Stress distribution over a fiber	Formulate stress distribution relative to fiber length
Fiber pull-out, fracture, bridging	Classify fiber strengthening/failure mechanisms Identify strategies to tailor composite design
Fiber Orientation Yield Criteria	Analyze failure theories based on fiber orientation

Teaching Philosophy and Approach

As an instructor, it is my responsibility to maximize opportunities for every student in the class to learn, grow, and succeed in reaching both my own outcomes for the course and their personal goals and desires related to the class. To meet this responsibility, I draw on theory, frameworks, and practices rooted in principles of collaborative learning and student-faculty partnership. For some students, this may feel awkward. Much of our society's discussions about teaching focus on a banking system, in which an instructor deposits knowledge into a student's mind, and students receive, file, store, and ultimately return that information in the same format in which it was deposited. Instead, I focus on student learning, which I define as a process of individual change. This means developing skills to view the world in new ways, and engaging in different types of debates, discussions, and dialogues.

Lectures:

The lectures are all pre-recorded and available to watch at the students' discretion via Brightspace. All students are expected to keep up with the materials and homework assignments and to live up to the highest standards of honesty and integrity. Lectures will include presentation of concepts and methods and working of examples. A typical class period will include a lecture highlighting the important concepts and integrating examples. Students are encouraged to use the Discussion Board to ask questions about the lectures. A pdf of the slides will be provided on Brightspace. Any notes written on the DocCam or annotations made on the slide presentations will not be provided, as it is expected that the students will take notes during the video lecture, including relevant points discussed by the instructor, as a means of active learning.

Homework:

Assigned weekly on the previous Tuesday (given on Brightspace) and due on the following Tuesday an hour before lecture. HW must be turned in via Brightspace on Tuesday by 9:30 am ET. HW submitted by other means (slipped under the door, in a mailbox, emailed directly to TA/instructor) will not be accepted, unless prior consent is given. Please start early on the assignment and check your solutions and files before submitting. Late HW will not be accepted. There will be approximately 10 HW assignments throughout this course.

The HW is for your own benefit and is necessary to properly learn the material. It is expected that each student put forward an honest effort in solving each problem. Although discussion of assignments between students is permitted, the solution should represent your own efforts and understanding of the problem. Blatant copies of the solutions will not be accepted, and repeated evidence of copying will lead to failure of the course.

Lastly, the purpose of homework assignments is for students to gain further understanding of classroom principles through application to practical problems. A critical aspect is problem solving and thinking about strategies to solve each question. This training is important to your overall understanding of the material and the ability to do well on the exams. HW will be graded based on approach, demonstration of work, and effort (not necessarily on the answer). Full credit will be given if the student has demonstrated that thought and effort has been put into the solution and the student is on the right track. If the question is not attempted, minimal effort is given, the student gives a flippant response, or the trajectory towards the solution is completely off path, then no credit will be given for this question. The grades will be posted on blackboard. The individual HW will not be marked up to identify where the student deviated from the path and give partial credit, as we would rather dedicate this time to put into spending time with students a priori and towards teaching. Instead, a detailed HW solution will be given to the students after the HW is submitted. This HW solution can be used as a study guide towards the exam.

Exams:

There will be one midterm exam and one final exam throughout the semester. The exams will be accumulative. The material on the exam will be closely related to the lectures and types of questions asked on the HW.

- *Midterm I – For students enrolled in CRN 28952, the exam will be Tuesday, October 29th from 8 to 10 pm in Gris 103. For students enrolled in CRN 31447, the exam will be taken with your proctor in the* *window of October 28th through October 30th (you need to register your proctor to EPE by October 21st). The exam will cover Lectures 1 thru 15 and HWs #1 thru 6. More information will be made available in Brightspace.*

- *Final Exam – Accumulative, but more heavily weighted to cover Lectures 16 thru 25 and HWs #7 thru 10. The date and time of the exam will be established by Purdue. Please look for an announcement in Brightspace.*

Exam solutions will not be distributed to the students but will be reviewed. Exam grades will not be openly discussed. If the students have grade appeals, they must submit a written appeal along with the original copy of their graded exams within one week of the exams being returned. The exam will be re-graded, which may reduce the overall grade, as any grading that was too generous may be corrected.

In Class Discussions:
In an effort to help facilitate in-class discussions, a schedule will be made and posted in the first two weeks of the semester. Each student signed up on the WNG section will need to be present in class on their assigned days and be prepared to ask informed questions to facilitate a discussion. Each student signed up for the EPE section will ask recap or clarification question(s) about the previous lecture. If students have a legitimate absence (in line with the guidance in this syllabus), they must let the instructor know they cannot accommodate the in class discussions prior to their date. Grades will be based on level of effort, engagement, and depth of discussion/questions.

Learning Resources, Technology, & Texts

- **Required Text:**
    - *Mechanical Behaviour of Engineering Materials: Metals, Ceramics, Polymers, and Composites*, Roesler, Joachim, Harders, Harald, Baeker, Martin; Springer, 2007; ISBN 978-3-540-73446-8.
        - Can be downloaded for Purdue students for via going through the Purdue library website and entering the title into the keyword search:
        - http://www.springer.com/materials/mechanics/book/978-3-540-73446-8
- **Recommended Text:**
    - "Mechanical Behavior of Materials," by William F. Hosford; Cambridge; ISBN-10: 0521846706
    - Online book: Defects in Crystals by Helmut Foll:
        - http://www.tf.uni-kiel.de/matwis/amat/def_en/index.html
- **Supplemental Texts** (for reference)**:**
    - *Mechanical Behavior of Materials*, Thomas H. Courtney, McGraw Hill
    - *Mechanical Behavior of Materials,* Norman E. Dowling, Prentice Hall
    - *Deformation and Fracture Mechanics of Engin. Material*, Richard W. Hertzberg, Wiley
    - *Materials Science and Engineering, An Introduction*, William D. Callister, Wiley
    - *Mechanics of Materials*, James M Gere & Barry J. Goodno, Cenage Learning
    - *Introduction to Dislocations*, D Hull & DJ Bacon, Butterworth-Heinemann
    - *Microstructural Design of Fiber Composites*, Tsu-Wei Chou, Cambridge
    - Theory of Dislocations, Hirth & Lothe, Krieger
    - *Crystals, Defects, and Microstructure,* Rob Phillips, Cambridge
- **Brightspace Page:**
    - You can access the course via Brightspace. It is strongly suggested that you explore and become familiar not only with the site navigation, but with content and resources available for this course. Additional handouts and course notes will be available via Brightspace.

Instructor's Email Availability and Policies

I will be available via email daily and try to respond as soon as possible (generally within 24-48) hours. When emailing me, please place the course number and the topic in the subject line of the email. This will help me tremendously in locating and responding to your emails quickly. I ask that all HW questions be asked either via the Brightspace discussion board or during the TA's office hours.

The schedule for office hours may change throughout the semester, in which case an announcement will be made through Brightspace.

Assignments and Points

Your learning will be assessed through a combination of homework, a project, midterm I, and midterm II spread throughout the semester. Details on these homework, exams, and project will be provided as assignments are provided to the students. The percentage breakdown is as follows:

- 25%: Homework – 10 HW assignments will be provided, of which, the highest 9 scores will count towards the students' grade. The due dates are indicated in the Course Schedule section.
- 35%: Midterm I
- 35%: Final Exam
- 5%: In class discussion leaders

Missed or Late Work

The student must notify me three business days before the due date if you need extra time to submit your assignment. Asking for an extension does not guarantee it will be granted. Without advance notice, late exams, homework assignments, or final projects will not be accepted without penalty unless there are extenuating circumstances beyond the student's control (e.g., illness, family emergency, bereavement, etc.). To ensure fairness in the class, the instructor will not make the solutions available until all students have turned in that assignment, including approved late submittals. If the solutions are posted, accept late assignments will no longer be accepted.

Grading Scale

In this class grades reflect the sum of your achievement throughout the semester. You will accumulate points as described in the assignments portion above, with each assignment graded according to a rubric. At the end of the semester, final grades will be calculated and translating into the following letters (there will be no partial points or rounding). Depending on how the class performs on its assignments and tests, the instructor reserves the right to curve the scale in the favor of the class, if necessary, based on his discretion. Grades will never be curved downward.

- A+: 96.5-100.0%
- A: 93.1-96.4%
- A-: 89.5-93.0%
- B+: 86.4-89.4%
- B: 83.1-86.4%
- B-: 79.5-83.0%
- C+: 76.4-79.4%
- C: 73.1-76.4%
- C-: 69.5-73.0%
- D+: 66.4-69.4%
- D: 63.1-66.4%
- D-: 59.5-63.0%
- F: 59.4% or below

Incompletes

According to the Grades and Grade Reports section of Academic Regulations, "A grade of incomplete (I) is a record of work that was interrupted by unavoidable absence or other causes beyond a student's control..." Further details on these circumstances and the process for assigning types of incompletes are outlined in the regulations. Please contact me as soon as you think an incomplete might be needed in this course and before final course grades are due.

Attendance Policy

This course is designed in a hybrid model, with some face-to-face meetings and others completed remotely. University policy states that students are expected to be present for every meeting of the classes in which they are enrolled. For the purposes of this course, being "present" means attending all face-to-face meetings unless you are ill or need to be absent for reasons excused by University regulations: grief/bereavement, military service, jury duty, parenting leave or certain medically excused absences (go to the Office of the Dean of Students (ODOS) website for details on how to submit those requests).

Being "present" also means participating remotely and completing work assigned for days when we do not meet face-to-face. This work is required to help you meet the course learning outcomes. These times count toward the course contact hours and your course grade.

Course Schedule

Below is an outline of topics with reading in parentheses, which correspond to sections in the Mechanical Behaviour of Engineering Materials: Metals, Ceramics, Polymers, and Composites text.

- Indicial Notation: Ch 1 and Appendix A
- Crystallography: Appendix B; 6.2.4
- Elasticity: Ch 2
- Stress-Strain Relationships and Yielding: 3.1-3.3.3; 3.5
- Dislocation Mechanics: 6.1 - 6.3
- Partial Dislocations and Stacking Faults
- Crystallographic Slip: 6.2
- Twinning and Shape Memory Effects: 6.5
- Strengthening Mechanisms: 6.4
- Creep: 11.1 – 11.2
- Two Bar Problems and Residual Stress
- Ceramics, Probability of Failure, and Statistical Variations: 7.1; 7.3; 7.5
- Polymer Structure, Deformation, Fracture, and Viscoelasticity: 8.1 – 8.8
- Composites: 9.1 – 9.4

Key University dates, include:

- Classes begin on Monday, August 19, 2024
- Labor Day is Monday, September 2, 2024
- October Break (No Classes) is October 7-8, 2024.
- Thanksgiving Break (No Classes) is November 27-30, 2024.
- Classes End on Saturday, December 7, 2024
- Final Exams are December 9-14, 2024.
- Commencement is Sunday, December 15, 2024
- Grades are due by 5:00pm on Tuesday, December 17, 2024

An Excel version of this schedule is available via Brightspace (under handouts). There are two tabs. Current will be updated with any modifications to the schedule. The original schedule is outlined below:

			Topic	Reading	HW Due Dates
	Week	**1**			
1	Tues	20-Aug	Into and Mechanics Prelim	Ch 1; App. A	
2	Thur	22-Aug	Crystallography	App. B; 6.2.4	
	Week	**2**			
3	Tues	27-Aug	Elasticity - physical basis and link to crystallography	Ch 2	
4	Thur	29-Aug	Elasticity - anisotropy; stress-strain relationship		
	Week	**3**			
5	Tues	3-Sep	States of Stress and Yielding, Ex of Rotation	3.1-3.3.3;3.5	1
6	Thur	5-Sep	Dislocation Mechanics - Basics & Elastic. Prop	6.1-6.2	
	Week	**4**			
7	Tues	10-Sep	Dislocation Mechanics - Energy and Forces	6.3	2
8	Thur	12-Sep	Dislocation Mechanics - Motion / Obstacles	6.2	
	Week	**5**			
9	Tues	17-Sep	Dislocations - Partials and Stacking faults	6.3	3
10	Thur	19-Sep	Plastic Deformation - single crystal	6.5	
	Week	**6**			
	Tues	24-Sep	***Class Canceled***		4
	Thur	26-Sep	***Class Canceled***		
	Week	**7**			
	Tues	1-Oct	***Class Canceled***		
11	Thur	3-Oct	Plastic Deformation polycrystal	6.4	
	Week	**8**			
	Tues	8-Oct	***No class - Fall Break***		
12	Thur	10-Oct	Twinning and Shape Memory*	6.4	
	Week	**9**			
13	Tues	15-Oct	Strength. Mech. - Solid Solution; Precip. Strengh.	7.1-7.2;7.5	5
14	Thur	17-Oct	Strength. Mech. - Strain Hardening; Grain Boundary	7.3	
	Week	**10**			
15	Tues	22-Oct	Review and Catch Up (if needed)		6
16	Thur	24-Oct	Creep - Overview, Phenomenon, and Larson Miller	11.1	
	Week	**11**			
17	Tues	29-Oct	Creep - Deformation Map and Example	11.2	
	Tue	29-Oct	***Midterm Exam I (L1-15, HW1-6): 8 - 10 pm in Gris 103***		
18	Thur	31-Oct	Two bar ex, residual stress, and contact mechanics		
	Week	**12**			
19	Tues	5-Nov	Ceramics and Weibull Statistics		7
20	Thur	7-Nov	Statistics; Probability of Failure; Property Variability		
	Week	**13**			
21	Tues	12-Nov	Polymer Structure	8.1;8.3;8.5-7	8
22	Thur	14-Nov	Polymer Time Dependency and Visco-Elasticity	8.2	
	Week	**14**			
23	Tues	19-Nov	Polymer Mechanical Behavior and Failure	8.4; 8.8	9
24	Thur	21-Nov	Composites Behavior-I	9.1-9.3	
	Week	**15**			
25	Tues	26-Nov	Composites Behavior-II	9.4	10
	Thur	28-Nov	***No class - Thanksgiving Break***		
	Week	**16**			
	Tues	3-Dec	***Class Canceled: Quiet Week***		
	Thur	5-Dec	***Class Canceled: Quiet Week***		
	Week 17				
			Finals TBD: Dec 9-14		

Academic Integrity

Academic integrity is one of the highest values that Purdue University holds. Individuals are encouraged to alert university officials to potential breaches of this value by either emailing integrity@purdue.edu or by calling 765-494-8778. While information may be submitted anonymously, the more information is submitted the greater the opportunity for the university to investigate the concern. More details are available on our course Brightspace table of contents, under University Policies. Students may refer to Purdue's [student guide for academic integrity].

The Honor Pledge Task Force, a student organization responsible for stewarding the mission of the Honor Pledge and encouraging a culture of academic integrity, has asked to prominently include the following student-initiated Purdue Honor Pledge on the syllabus, as well as exams and HW assignments:

The Purdue Honor Pledge "As a boilermaker pursuing academic excellence, I pledge to be honest and true in all that I do. Accountable together - we are Purdue"

In general, notes, exams, exam solutions, homework, and homework solutions are considered to be *'derivative works'* of the instructor's presentations and materials, and they are thus subject to the instructor's copyright in such presentations and materials. As such, they cannot be sold or bartered without express written permission of the instructor. Specifically, you are ***not*** allowed to post any course materials or derivative works of this class on commercial websites.

Nondiscrimination Statement

Purdue University is committed to maintaining a community that recognizes and values the inherent worth and dignity of every person; fosters tolerance, sensitivity, understanding, and mutual respect among its members; and encourages each individual to strive to reach his or her potential. In pursuit of its goal of academic excellence, the University seeks to develop and nurture diversity. The University believes that diversity among its many members strengthens the institution, stimulates creativity, promotes the exchange of ideas, and enriches campus life. A hyperlink to Purdue's full Nondiscrimination Policy Statement is included in our course Brightspace under University Policies.

The School of Aeronautics and Astronautics is also committed to a climate of inclusion; if you need to report an issue of hate or bias, you may use the link at the top right of our page here:https://engineering.purdue.edu/AAE/aboutus/Diversity/index_html.

Accessibility

Purdue University strives to make learning experiences as accessible as possible. If you anticipate or experience physical or academic barriers based on disability, you are welcome to let me know so that we can discuss options. You are also encouraged to contact the Disability Resource Center at: drc@purdue.edu or by phone: 765-494-1247. More details are available on our course Brightspace under Accessibility Information. Students with a Letter of Accommodation from Disability Resource Center should let the instructor know.

Emergency Preparation

In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances beyond the instructor's control. Relevant changes to this course will be posted onto the course website or can be obtained by contacting the instructors or TAs via email or phone. You are expected to read your @purdue.edu email on a frequent basis.

Mental Health Statement

The following resources are available to help address mental health among students enrolled at Purdue University

- **If you find yourself beginning to feel some stress, anxiety and/or feeling slightly overwhelmed,** try WellTrack. Sign in and find information and tools at your fingertips, available to you at any time.

- **If you need support and information about options and resources,** please contact or see the Office of the Dean of Students. Call 765-494-1747. Hours of operation are M-F, 8 am- 5 pm.
- **If you find yourself struggling to find a healthy balance between academics, social life, stress, etc.** sign up for free one-on-one virtual or in-person sessions with a Purdue Wellness Coach at RecWell. Student coaches can help you navigate through barriers and challenges toward your goals throughout the semester. Sign up is completely free and can be done on BoilerConnect. If you have any questions, please contact Purdue Wellness at evans240@purdue.edu.
- **If you're struggling and need mental health services:** Purdue University is committed to advancing the mental health and well-being of its students. If you or someone you know is feeling overwhelmed, depressed, and/or in need of mental health support, services are available. For help, such individuals should contact Counseling and Psychological Services (CAPS) at 765-494-6995 during and after hours, on weekends and holidays, or by going to the CAPS office of the second floor of the Purdue University Student Health Center (PUSH) during business hours.

Copyright

Effective learning environments provide opportunities for students to reflect, explore new ideas, post opinions openly, and have the freedom to change those opinions over time. Students and instructors are the authors of the works they create in the learning environment. As authors, they own the copyright in their works subject only to the university's right to use those works for educational purposes (see the Purdue University Copyright Office website) Students may not copy, reproduce, or post to any other outlet (e.g., YouTube, Facebook, or other open media sources or websites) any work in which they are not the sole or joint author or have not obtained the permission of the author(s).

Netiquette

We want to foster a safe online learning environment. All opinions and experiences, no matter how different or controversial they may be perceived, must be respected in the tolerant spirit of academic discourse. You are encouraged to comment, question, or critique an idea, but you may not attack an individual. Our differences, some of which are outlined in the University's nondiscrimination statement below, will add richness to this learning experience. Please consider that sarcasm and humor can be misconstrued in online interactions and generate unintended disruptions. Working as a community of learners, we can build a polite and respectful course ambience. Please read the Netiquette rules for this course:

- Monitor how much space/time you are taking up in any discussion. Give other students the opportunity to join in the discussion.
- Do not use offensive language. Present ideas appropriately.
- Be cautious in using Internet language. For example, do not capitalize all letters since this suggests shouting.
- Avoid using vernacular and/or slang language. This could lead to misinterpretation.
- Keep an "open-mind" and be willing to express even your minority opinion.
- Think and edit before you push the "Send" button.
- Seek and take in feedback from others; learning from other people is an important life skill.

Violent Behavior Policy

Purdue University is committed to providing a safe and secure campus environment for members of the university community. Purdue strives to create an educational environment for students and a work environment for employees that promote educational and career goals. Violent behavior impedes such goals. Therefore, violent behavior is prohibited in or on any University facility or while participating in any university activity. See the Student Resource widget on our course Brightspace for more information on the Violent Behavior Policy.

Diversity, Inclusion & Belonging Statement

Purdue University is committed to maintaining a community which recognizes and values the inherent worth and dignity of every person; fosters tolerance, sensitivity, understanding, and mutual respect among its members; and encourages each individual to strive to reach his or her own potential. In pursuit of its goal of academic excellence, the University seeks to develop and nurture diversity. The University believes that diversity among its many members strengthens the institution, stimulates creativity, promotes the exchange of ideas, and enriches campus life. More details are available on our course Brightspace table of contents, under University Policies.

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https://engineering.purdue.edu/AAE/aboutus/Diversity/index_html

1. In our discussions, structured and unstructured, we will explore a variety of challenging issues, which can help us enhance our understanding of different experiences and perspectives. This can be challenging, but in overcoming these challenges we find the greatest rewards. While we will design guidelines as a group, everyone should remember the following points:
    - We are all in the process of learning about others and their experiences. Please speak with me, anonymously if needed, if you have concerns about aspects of/experiences in the course.
    - Intention and impact are not always aligned, and we should respect the impact something may have on someone even if it was not the speaker's intention.
    - We all come to the class with a variety of experiences and a range of expertise, we should respect these in others while critically examining them in ourselves."
2. This course, as with every course offered at Purdue, plays a part in creating and sustaining a welcoming campus where all students can excel. There are many initiatives in AAE department and supported by the university focused on this goal, and this course is designed to take advantage of those resources. Learning experiences and assignments address diversity and inclusion, not because they are "topics," but because they are necessary to prepare students to be successful in a diverse, global environment.

3. We strive for equity, providing equal access and opportunity, and working to maximize student potential. This requires both instructor and students to identify and remove barriers that may prevent someone from full access or full participation. You can help by:
    - Contacting me, anonymously if needed, if you see a potential barrier for someone or yourself in participating fully in the class. This might be a physical barrier such as access to technology or a personal situation.
    - Suggesting ways in which members of our class can support each other. Virtual study groups and discussion boards are examples, but I encourage you to be creative in your ideas.
    - Getting to know each other as contributing members of our learning community. Everyone has something to contribute, and while I designed the course to take advantage of the wealth of knowledge, expertise, and experience we bring together, I cannot do it well without your participation. There are many opportunities built into this course for this type of work. It is important we do it together.

Basic Needs Security

Any student who faces challenges securing their food or housing and believes this may affect their performance in the course is urged to contact the Dean of Students for support. There is no appointment needed and Student Support Services is available to serve students 8 a.m.-5 p.m. Monday through Friday. Considering the significant disruptions caused by the current global crisis as it relates to COVID-19, students may submit requests for emergency assistance from the Critical Need Fund

Course Evaluation

Toward the end of this semester, you will be provided with an opportunity to give feedback on this course and your instructor. Purdue uses an online course evaluation system. You will receive an official email from evaluation administrators with a link to the online evaluation site and will receive a prompt to complete the survey when you login to Brightspace. Your participation is an integral part of this course, and your feedback is vital to improving education at Purdue University. I strongly urge you to participate in the evaluation system.

Student Help and Success

Your Brightspace course shell includes links to the following student resources under the Student Help and Success content, from here you may find links to the following student services.

- Registrar
- Financial Aid
- Academic Advising
- Veterans Success Center
- Student Employment
- Center for Career Opportunities.

Disclaimer

This syllabus is subject to change. You will be notified of any changes as far in advance as possible via an announcement on Brightspace. Monitor your Purdue email daily for updates.