Engineering Faculty Document No. 78-21
2/18/2021

TO: The Faculty of the College of Engineering

FROM: The Faculty of the School of Materials Engineering

RE: New Graduate Course – MSE 52400: Mechanical Behavior of Polymers

MSE 52400 MECHANICAL BEHAVIOR OF POLYMERS
SEM 1 or 2, Lecture 3, cr. 3
Graduate Standing OR [MSE 382]

COURSE DESCRIPTION: This course is about the fundamental bulk mechanical behavior of polymeric materials. The focus is on solid mechanics concepts of elasticity (linear, Neo-Hookean, rubber, etc.), viscoelasticity (rheology and time-temperature superposition), and deformation behaviors specific to soft matter (crazing, necking, drawing, etc.). This will be done primarily through continuum mechanics principles with short discussions of how molecular properties influence bulk behavior.

REASON: The course is designed to meet the needs of students within the School of Materials Engineering (MSE), and potentially other engineering majors studying mechanics of materials. The course fits within the polymeric materials research area of the School of MSE and will enable bulk mechanical properties of polymers to be introduced to graduate students in greater detail. MSE 52400 will serve as one of the two foundational courses for incoming soft matter graduate students to MSE (with MSE 52500 – Molecular Physics of Polymers). Previously, MSE 25000 was offered as a single 3 credit hour course to cover both the molecular and bulk properties of polymers. By separating the topics roughly by size-scale of interest, MSE 52400 and MSE 52500 will comprise the foundational or core courses that serve as prerequisites for many of the other graduate level polymer courses offered by MSE.

David Bahr
Professor and Head
School of Materials Engineering
Purdue University

Proposal for New Graduate Level Course for Academic Review
MSE 52400 – Mechanical Behavior of Polymers

Note: The detailed course proposal is intended for academic review by the appropriate area committee of the Graduate Council. It supplements the Form 40G that is intended for administrative review of the Graduate School and Registrar.

TO: Purdue University Graduate Council

FROM: Faculty Member: Chelsea Davis
Department: School of Materials Engineering
Campus: West Lafayette

DATE: March 13, 2020

SUBJECT: Proposal for New Graduate Course

MSE 52400 MECHANICAL BEHAVIOR OF POLYMERS
SEM 1 or 2, Lecture 3, cr. 3

1. Course Description

This course will focus on the mechanical properties and behaviors of polymeric materials. The course will utilize fundamental solid and fluid mechanics to understand the response of bulk polymers (solid and liquid, above and below T_g). The impact of deformation rate and temperature on the mechanical response of polymers will be covered in detail. The course will start with an overview of linear elastic mechanics, move to rubber elasticity, and then viscoelasticity (concentrating on time-temperature superposition). We will also cover fluid dynamics and the rheology of non-Newtonian fluids. We will conclude with a section on deformation, yield, and fracture mechanisms (focusing on those phenomena that are unique to polymers such as rubber cavitation, drawing, and crazing).

2. Justification for the Course

2.1 Justification of the need for the course

The course is designed to meet the needs of students within the School of Materials Engineering (MSE), and potentially other engineering majors studying mechanics of materials. The course fits within the polymeric materials research area of the School of MSE and will enable bulk mechanical properties of polymers to be introduced to graduate students. MSE 52400 will serve as one of the two foundational courses for incoming soft matter graduate students to MSE (in conjunction with MSE 52500 – Molecular Physics of Polymers). Previously, MSE 52500 was offered as a single 3 credit hour course to cover both the molecular and bulk properties of polymers. By separating the topics roughly by size-scale of interest, MSE 52400 and MSE 52500 will comprise the foundational or core courses that serve as prerequisites for many of the other graduate level polymer courses offered by MSE.

2.2 Justification that course will be taught at a graduate level

MSE 52400 will be taught at the graduate level. The course material is divided roughly into three units and each unit utilizes advanced primary and secondary sources. A different advanced textbook is recommended for each unit (An Introduction to The Mechanical Properties of Solid Polymers by Ward and Sweeney, Introduction to Polymer Viscoelasticity by Shaw and MacKnight, and Principles of Polymer Engineering by McCrum, Buckley, and Bucknall). Additionally, several class periods are devoted to discussions of specific primary sources and focus on introducing students to the seminal peer-reviewed journal articles in the field.

Assessment is achieved through two in-class exams and a final exam. Each exam requires intensive problem solving and the utilization of concepts covered in class to reason through hypothetical data analysis and interpretation scenarios.

Topics in the course range from classical (most of polymer mechanical theory is from the mid20th century) to current. Students are encouraged to ask questions specific to phenomena that they are observing in their own experimental research projects in class.

While the final grades for the course are curved, undergraduate students are not assessed separately from the graduate students and are expected to perform at the same level.

3. Learning Outcomes and Methods of Assessment

3.1 Learning Outcomes

1. Demonstrate fundamental understanding of solid mechanics: draw a free body diagram and employ the correct equations of state to solve two- and three-dimensional statics and solids problems.
2. Articulate key concepts in rubber elasticity.
3. Utilize time-temperature superposition to generate a master curve to fully describe the mechanical response of a viscoelastic material. Apply "spring and dashpot" models to describe nonlinear materials responses.
4. Describe a rheology experiment of a non-Newtonian fluid: interpret and analyze raw rheology data, identify key phase transitions.
5. Solve simple fracture mechanics problems. Demonstrate an understanding of polymer deformation mechanisms. Apply polymer yield criteria to predict failure resulting from a given loading scenario.

3.2 Assessment Methods

All assessments will be achieved through three exams (two midterms and a final exam). Each exam will require complex problem solving and reasoning. These exams will be designed to assess student's knowledge of bulk polymer mechanical behavior, their skills in assessing and interpreting stress-strain behavior of viscoelastic materials, and their knowledge gained from the supplementary course readings.

Several homework sets will be assigned throughout the term to reinforce the information covered during lecture. This homework will not be collected or graded but solutions to the more

difficult problems will be covered in detail in class and during extracurricular review sessions held prior to each of the three exams.

3.3 Final Grading Criteria

Each exam will be weighted equally (33% each) towards the final course grade. Graduate and undergraduate students will be evaluated together and a single curve will be applied to the final grade assignments if necessary.

3.4 Methods of Instruction

Lecture – Lectures will be used to help the students to achieve the learning outcomes. These include hands-on analyses of basic principles of concepts covered during lectures.

3.5 Corequisite(s)

Graduate Standing OR [MSE 382]

4. Course Instructor

Chelsea Davis, Assistant Professor, MSE, member of the Graduate Faculty:

Prof. Davis has experience and training in polymer science and experimental mechanics. In particular, in addition to her PhD in polymer science and engineering, she has postdoctoral training in experimental bulk mechanical testing of soft matter interfaces and has several papers in the field of polymer mechanics.

5. Course Outline:

1. Introduction to mechanics of polymers
2. Statics of rigid bodies
3. Mechanics of solids
4. Fluid mechanics
    a. Newtonian fluids
    b. Non-Newtonian fluids
5. Viscoelasticity
    a. Concepts and experimental design
    b. Creep and stress relaxation
    c. Spring and dashpot models
    d. Time-temperature superposition
6. Rheology
    a. Concepts and experimental design
    b. Data analysis and interpretation
7. Deformation, yield, and fracture of polymers
    a. Thermoplastic yielding
        i. Necking
        ii. Crazing
        iii. Cold-drawing

b. Yield stress criteria
c. Contact mechanics
    i. Hertz, JKR, and DMT theories
d. Fracture and environmental stress cracking

8. Auxetic and metamaterials

6. Reading List

- IM Ward and J Sweeney An Introduction to The Mechanical Properties of Solid Polymers, 3rd ed., Wiley. ISBN: 9781444319507 (The 2nd ed. is available in paperback for $67 on Amazon).

- NG McCrum, CP Buckley, CB Bucknall Principles of Polymer Engineering, 2nd ed., Oxford ISBN: 9780198565260

- MT Shaw & WJ MacKnight Introduction to Polymer Viscoelasticity, 3rd ed., Wiley ISBN: 9780471740452

- PA Kelly Solid Mechanics Part I: An Introduction to Solid Mechanics, Online Resource: http://homepages.engineering.auckland.ac.nz/~pkel015/SolidMechanicsBooks/Part_I/index.html

Note: Purdue libraries have the books, either in hardcopy or available electronically.

MSE 59700-007
Mechanical Properties and Behaviors of Polymers
or
Fundamental Concepts of Polymer Engineering

Instructor: Prof. Chelsea Davis

Office: ARMS 2229

Phone: 765.494.9216

Email: Chelsea@purdue.edu

Office Hours: Tuesday 3pm-4pm or by appointment

Instructor's Website: PolymerInterfacialMechanics.com

Course Information

Fall 2019

MWF 10:30am – 11:20am

PHYS B012

Course Credit Hours: 3.0

Course Webpage: Blackboard

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Corequisites

MSE 38200 Mechanics of Materials or equivalent is the corequisite for this course. Alternatively, any graduate student may take this course, with the understanding that a basic knowledge of statics and mechanics will be assumed.

Additionally, students are expected to review and learn any basic skills (calculus, linear algebra, etc.) that are assumed to be a baseline for any engineering student taking a graduate level course.

Learning Outcomes

1. Demonstrate fundamental understanding of **solid mechanics**: draw a free body diagram and employ the correct equations of state to solve two- and three-dimensional statics and solids problems.
2. Articulate key concepts in **rubber elasticity**.
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Policies

General Course Policies

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If you feel that I have made an error in grading one of your exams, I am open to discussing the disputed points. Grade appeals should be made during my office hours (see above) or by appointment and not during or after class. Grade appeals can only be made within 7 days of the return of the graded exam. After that, the assigned grade will stand.

To appeal your grade, submit a written justification of what you believe was the error in grading as well as a copy of your graded exam (either through email or placed in my faculty mailbox in ARMS 2300). The written appeal should be submitted at least 12 hours before an in-person meeting in my office. Note that I will regrade the entire exam, not just the problem(s) that you have identified. Your grade could be revised down if I discover an incorrect problem that I had initially given credit for.

Academic Dishonesty

"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 that is submitted provides the greatest opportunity for the university to investigate the concern."

I expect that all exams reflect your own individual effort. If you are planning on cheating or feel the need to use the effort of others instead of your own, you should rethink your enrollment in this class. Academic dishonesty will ultimately hurt you as you move through your academic career without learning the material.

Any student caught cheating on an exam will receive an F in the course and will be reported to the Office of Student Rights and Responsibilities.

Use of Copyrighted Materials

This is the second year that this course, in its present form, has been offered. That means that I am still working to develop the course materials in real time. Please don't nullify that effort by posting my lecture notes, problem sets and/or exams online.

The University policy on the use of copyrighted materials is:

Students are expected, within the context of the Regulations Governing Student Conduct and other applicable University policies, to act responsibly and ethically by applying the appropriate exception under the Copyright Act to the use of copyrighted works in their activities and studies. The University does not assume legal responsibility for violations of copyright law by students who are not employees of the University.

A Copyrightable Work created by any person subject to this policy primarily to express and preserve scholarship as evidence of academic advancement or academic accomplishment. Such works may include, but are not limited to, scholarly publications, journal articles, research bulletins, monographs, books, plays, poems, musical compositions and other works of artistic imagination, and works of students created in the course of their education, such as exams, projects, theses or dissertations, papers and articles.

Attendance

Lecture/Problem Sessions

I will not be taking attendance. I hope that you will attend every class, but the choice is yours. You are still responsible for all course material (much of which will not be in the main textbooks). If you are planning on missing a class or two, I do not need (or want) to be informed. Simply make arrangements to get the lecture notes from a classmate.

Exams

Please make every reasonable effort to attend each of the three exams. However, if you do need to miss an exam, make sure that it is for an acceptable reason.

Acceptable reasons for missing an exam include recognized University sponsored activities, serious illness, bereavement, and military leave per the stated University attendance policy guidelines. In each case, documentation of the reason for the absence is required.

Unacceptable reasons for missing an exam are work schedule conflicts, overload from other courses/research, poor study conditions, car trouble, dogs eating study materials, etc.

Missed Exam

If you need to miss an exam, I need to be informed at least one full week before the exam date to schedule a makeup time. No makeup exams will be allowed if you fail to attend the in-class exam without prior notification (except for one of the acceptable, documented reasons noted above).

Grief Absence Policy for Students

Below is the University's Grief Absence Policy for Students:

Purdue University recognizes that a time of bereavement is very difficult for a student. The University therefore provides the following rights to students facing the loss of a family member through the Grief Absence Policy for Students (GAPS). GAPS Policy: Students will be excused for funeral leave and given the opportunity to earn equivalent credit and to demonstrate evidence of meeting the learning outcomes for missed assignments or assessments in the event of the death of a member of the student's family.

See the University's website for additional information:
http://www.purdue.edu/studentregulations/regulations_procedures/classes.html

Violent Behavior Policy
Below is Purdue's policy prohibiting violent behavior:

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 University's website for additional information:
http://www.purdue.edu/policies/facilities-safety/iva3.html

Emergencies
If a major campus emergency occurs on an exam date, the exam will take place during the next class period after we have resumed our regular academic schedule.

Below is Purdue's policy regarding campus emergencies:

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.

See the University's website for additional information:
https://www.purdue.edu/ehps/emergency_preparedness/

Accessibility and Accommodations
Since the grade for this course is based on three exam grades, I will work with the DRC to accommodate any reasonable testing alternatives. Please present your letter requesting accommodation from the DRC within the first three weeks of class. I will either provide tests to the DRC or schedule an alternative testing location.

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.

Nondiscrimination
This course will involve significant teamwork. Please keep in mind the importance of maintaining an open and welcoming learning environment for all students.

Below is Purdue's policy statement for nondiscrimination.

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.

Purdue University views, evaluates, and treats all persons in any University related activity or circumstance in which they may be involved, solely as individuals on the basis of their own personal abilities, qualifications, and other relevant characteristics.

Purdue University prohibits discrimination against any member of the University community on the basis of race, religion, color, sex, age, national origin or ancestry, genetic information, marital status, parental status, sexual orientation, gender identity and expression, disability, or status as a veteran. The University will conduct its programs, services and activities consistent with applicable federal, state and local laws, regulations and orders and in conformance with the procedures and limitations as set forth in Purdue's Equal Opportunity, Equal Access and Affirmative Action policy which provides specific contractual rights and remedies. Additionally, the University promotes the full realization of equal employment opportunity for women, minorities, persons with disabilities and veterans through its affirmative action program.

Any question of interpretation regarding this Nondiscrimination Policy Statement shall be referred to the ***Vice President for Ethics and Compliance*** *for final determination.*

See Purdue's nondiscrimination statement:
http://www.purdue.edu/purdue/ea_eou_statement.html

Disclaimer
This syllabus is subject to change.

Class Schedule

Class Period	Topic	Subtopic and notes	Text/Ref
20-Aug	Review: Mechanics of Materials	Solid Mechanics Overview	Kelly Ch1
22-Aug		Traction Forces and Moments	Kelly Ch2
24-Aug		Free Body Diagrams	Kelly Ch2
27-Aug			Kelly Ch2
29-Aug			Kelly Ch2
31-Aug	Stress	Normal, distributed loads, shear	Kelly Ch3, W&S Ch2.1
3-Sep	No Class	Labor Day	
5-Sep	Stress	Normal, distributed loads, shear	Kelly Ch3, W&S Ch2.1
7-Sep	Strain	Plane, shear, eng vs. true	Kelly Ch4, W&S Ch2.2
10-Sep	Mechanics of Materials	Definitions	Kelly Ch5
12-Sep		Linear Elasticity - Constitutive Models	Kelly Ch6
14-Sep			Kelly Ch6
17-Sep		Linear Elasticity - Applications (columns, beams)	Kelly Ch7
19-Sep		Non-Linear Elasticity - Rubber and Filled Systems	Kelly Ch7, W&S Ch3
21-Sep		Viscoelasticity - Concepts and test methods	Kelly Ch10, W&S Ch4.1, Ch10
24-Sep		Viscoelasticity - Modeling VE response	Kelly Ch10, W&S Ch4.2
26-Sep			Kelly Ch10, W&S Ch10
28-Sep			Kelly Ch10, W&S Ch10
1-Oct	Review Session		
3-Oct	Exam 1 - Solid Mechanics		
5-Oct	No Class	October Break	
8-Oct	No Class		
10-Oct	Viscoelasticity - Modeling VE response	Spring and Dashpot	Kelly Ch10, W&S Ch4.2, S&MacK
12-Oct		HW #4	
15-Oct			
17-Oct			
19-Oct	Rheology - Concepts	Erk Guest Lecture	Shaw&MacKnight

Class Period	Topic	Subtopic and notes	Text/Ref
22-Oct	Rheology - Data analysis and interpretation		Shaw&MacKnight
24-Oct	Molecular Theories (Rouse and Zimm)	HW #5	Shaw&MacKnight
26-Oct	Viscoelasticity - Concepts and test methods		Shaw&MacKnight
29-Oct			Shaw&MacKnight
31-Oct	Time Temperature Superposition (WLF)		Shaw&MacKnight
2-Nov		HW #6	Shaw&MacKnight
5-Nov	VE Flow - Non-Newtonian Fluids		Shaw&MacKnight
7-Nov	VE Solids Review		
9-Nov	Exam 2 – Viscoelasticity		
12-Nov	Thermoplastic Yield - Crazing		
14-Nov	Yield Stress Criteria		
16-Nov		HW #7	
19-Nov			
21-Nov	Thanksgiving - No Class		
23-Nov			
26-Nov	Fracture	Griffith Criterion	
28-Nov		Crack Blunting	
30-Nov	Rubber Toughening and Cavitation	HW #8	
3-Dec	Auxetic Materials	Dead Week	
5-Dec	Review Session		
7-Dec			
13-Dec	Final Exam –Cumulative	10:30am-12:30pm ARMS B071	

7. Course Syllabus

• MSE 59700-007
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or
Fundamental Concepts of Polymer Engineering

Instructor: Prof. Chelsea Davis

Office: ARMS 2229

Phone: 765.494.9216

Email: Chelsea@purdue.edu

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A Copyrightable Work created by any person subject to this policy primarily to express and preserve scholarship as evidence of academic advancement or academic accomplishment. Such works may include, but are not limited to, scholarly publications, journal articles, research bulletins, monographs, books, plays, poems, musical compositions and other works of

artistic imagination, and works of students created in the course of their education, such as exams, projects, theses or dissertations, papers and articles.

- **Attendance**

Lecture/Problem Sessions

I will not be taking attendance. I hope that you will attend every class, but the choice is yours. You are still responsible for all course material (much of which will not be in the main textbooks). If you are planning on missing a class or two, I do not need (or want) to be informed. Simply make arrangements to get the lecture notes from a classmate.

Exams

Please make every reasonable effort to attend each of the three exams. However, if you do need to miss an exam, make sure that it is for an acceptable reason.

Acceptable reasons for missing an exam include recognized University sponsored activities, serious illness, bereavement, and military leave per the stated University attendance policy guidelines. In each case, documentation of the reason for the absence is required.

Unacceptable reasons for missing an exam are work schedule conflicts, overload from other courses/research, poor study conditions, car trouble, dogs eating study materials, etc.

- **Missed Exam**

If you need to miss an exam, I need to be informed at least one full week before the exam date to schedule a makeup time. No makeup exams will be allowed if you fail to attend the in-class exam without prior notification (except for one of the acceptable, documented reasons noted above).

- **Grief Absence Policy for Students**

Below is the University's Grief Absence Policy for Students:

Purdue University recognizes that a time of bereavement is very difficult for a student. The University therefore provides the following rights to students facing the loss of a family member through the Grief Absence Policy for Students (GAPS). GAPS Policy: Students will be excused for funeral leave and given the opportunity to earn equivalent credit and to demonstrate evidence of meeting the learning outcomes for missed assignments or assessments in the event of the death of a member of the student's family.

See the University's website for additional information:
http://www.purdue.edu/studentregulations/regulations_procedures/classes.html

- **Violent Behavior Policy**

Below is Purdue's policy prohibiting violent behavior:

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 University's website for additional information:
http://www.purdue.edu/policies/facilities-safety/iva3.html

- **Emergencies**

If a major campus emergency occurs on an exam date, the exam will take place during the next class period after we have resumed our regular academic schedule.

Below is Purdue's policy regarding campus emergencies:

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.

See the University's website for additional information:
https://www.purdue.edu/ehps/emergency_preparedness/

Accessibility and Accommodations

Since the grade for this course is based on three exam grades, I will work with the DRC to accommodate any reasonable testing alternatives. Please present your letter requesting accommodation from the DRC within the first three weeks of class. I will either provide tests to the DRC or schedule an alternative testing location.

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.

- **Nondiscrimination**

This course will involve significant teamwork. Please keep in mind the importance of maintaining an open and welcoming learning environment for all students.

Below is Purdue's policy statement for nondiscrimination.

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.

Purdue University views, evaluates, and treats all persons in any University related activity or circumstance in which they may be involved, solely as individuals on the basis of their own personal abilities, qualifications, and other relevant characteristics.

Purdue University prohibits discrimination against any member of the University community on the basis of race, religion, color, sex, age, national origin or ancestry, genetic information, marital status, parental status, sexual orientation, gender identity and expression, disability, or status as a veteran. The University will conduct its programs, services and activities consistent with applicable federal, state and local laws, regulations and orders and in conformance with the procedures and limitations as set forth in Purdue's Equal Opportunity, Equal Access and Affirmative Action policy which provides specific contractual rights and remedies. Additionally, the University promotes the full realization of equal employment opportunity for women, minorities, persons with disabilities and veterans through its affirmative action program.

Any question of interpretation regarding this Nondiscrimination Policy Statement shall be referred to the ***Vice President for Ethics and Compliance*** *for final determination.*

See Purdue's nondiscrimination statement:
http://www.purdue.edu/purdue/ea_eou_statement.html

• Disclaimer

This syllabus is subject to change.

- Class Schedule

Class Period	Topic	Subtopic and notes	Text/Ref
20-Aug	Review: Mechanics of Materials	Solid Mechanics Overview	Kelly Ch1
22-Aug		Traction Forces and Moments	Kelly Ch2
24-Aug		Free Body Diagrams	Kelly Ch2
27-Aug			Kelly Ch2
29-Aug			Kelly Ch2
31-Aug	Stress	Normal, distributed loads, shear	Kelly Ch3, W&S Ch2.1
3-Sep	No Class	Labor Day	
5-Sep	Stress	Normal, distributed loads, shear	Kelly Ch3, W&S Ch2.1
7-Sep	Strain	Plane, shear, eng vs. true	Kelly Ch4, W&S Ch2.2
10-Sep	Mechanics of Materials	Definitions	Kelly Ch5
12-Sep		Linear Elasticity - Constitutive Models	Kelly Ch6
14-Sep			Kelly Ch6
17-Sep		Linear Elasticity - Applications (columns, beams)	Kelly Ch7
19-Sep		Non-Linear Elasticity - Rubber and Filled Systems	Kelly Ch7, W&S Ch3
21-Sep		Viscoelasticity - Concepts and test methods	Kelly Ch10, W&S Ch4.1, Ch10
24-Sep		Viscoelasticity - Modeling VE response	Kelly Ch10, W&S Ch4.2
26-Sep			Kelly Ch10, W&S Ch10
28-Sep			Kelly Ch10, W&S Ch10
1-Oct	Review Session		
3-Oct	Exam 1 - Solid Mechanics		
5-Oct	No Class	October Break	
8-Oct	No Class		
10-Oct	Viscoelasticity - Modeling VE response	Spring and Dashpot	Kelly Ch10, W&S Ch4.2, S&MacK
12-Oct		HW #4	
15-Oct			
17-Oct			
19-Oct	Rheology - Concepts	Erk Guest Lecture	Shaw&MacKnight

Class Period	Topic	Subtopic and notes	Text/Ref
22-Oct	Rheology - Data analysis and interpretation		Shaw&MacKnight
24-Oct	Molecular Theories (Rouse and Zimm)	HW #5	Shaw&MacKnight
26-Oct	Viscoelasticity - Concepts and test methods		Shaw&MacKnight
29-Oct			Shaw&MacKnight
31-Oct	Time Temperature Superposition (WLF)		Shaw&MacKnight
2-Nov		HW #6	Shaw&MacKnight
5-Nov	VE Flow - Non-Newtonian Fluids		Shaw&MacKnight
7-Nov	VE Solids Review		
9-Nov	Exam 2 – Viscoelasticity		
12-Nov	Thermoplastic Yield - Crazing		
14-Nov	Yield Stress Criteria		
16-Nov		HW #7	
19-Nov			
21-Nov	Thanksgiving - No Class		
23-Nov			
26-Nov	Fracture	Griffith Criterion	
28-Nov		Crack Blunting	
30-Nov	Rubber Toughening and Cavitation	HW #8	
3-Dec	Auxetic Materials	Dead Week	
5-Dec	Review Session		
7-Dec			
13-Dec	Final Exam –Cumulative	10:30am-12:30pm ARMS B071	