

# USC Viterbi

School of Engineering  
*Sonny Astani Department  
of Civil and Environmental  
Engineering*

## **CE 599 Special Topics: Mechanics of Soft Materials and 3D Printing**

**Units:** 3

**Spring—Day—Time:** 2019 Fall, Friday, 1:00-3:50PM

**Location:** WPH 400

**Instructor:** Qiming Wang

**Office:** BHE 222

**Office Hours:** Tuesday, Wednesday 3-5 PM or by appointment

**Contact Info:** [qimingw@usc.edu](mailto:qimingw@usc.edu)

**Teaching Assistant:** TBD

**Office:**

**Office Hours:**

**Contact Info:**

**IT Help:** TBD

**Hours of Service:**

**Contact Info:**

## Course Description

### Catalogue Description

Polymer elasticity; Viscoelasticity; Mechanics of stimuli-responsive polymers; Mechanics of Fused Deposit Modeling (FDM); Mechanics of Stereolithography (STL).

### Extended Course Description

The course will cover the fundamental mechanics knowledge of soft materials and 3D printing technologies. The course will be divided into two parts. In the first part (lectures 1-8), mechanics of soft materials will be covered, and then these theories will be extended to understand the mechanics of stimuli-responsive materials such as electroactive polymers and hydrogels. In the second part (lecture 9-14), the mechanics theories will be further extended to understand the mechanics problems related to emerging 3D printing technologies, such as Fused Deposition Modeling (FDM), Stereolithography (STL), and Selective Laser Sintering (SLS).

### Learning Objectives and Outcomes

The course will serve as a basis of mechanics of deformable solids that can be connected to various branches of solid mechanics, such as Soil Mechanics, Mechanics of Composite Materials, Nonlinear Finite Element Methods, Geotechnical Mechanics, Structural Stability, Plates and Shells. The course is valuable for students who are pursuing research in Engineering Mechanics, Stabilities of Structures and Materials, Polymer Mechanics, and 3D printing. This course may also be valuable for practicing engineers or scientists who are working on solid mechanics and structures or 3D printing.

**Recommended Preparation:** Undergraduate strength of materials class on the level of CE 225.

### Course Notes

Lecture notes written by the instructor will be distributed to students through the blackboard system prior to the corresponding lectures. The lecture notes will cover the essential contents and supplementary information of the lectures. The lecture notes will be treated as reading materials to support the lectures.

### Reference Materials

The following optional textbooks can be supplementary materials for the course:

1. Gerhard A. Holzapfel, "Nonlinear Solid Mechanics: A continuum Approach for Engineering", Wiley, 2000, 1<sup>st</sup> Edition, ISBN-13: 978-0471823193.
2. L.R.G. Treloar, "The Physics of Rubber Elasticity", Oxford University Press, 2005, 3<sup>rd</sup> edition, ISBN-13: 978-0198570271.
3. M. Rubinstein, Ralph H. Colby, "Polymer Physics", Oxford University Press, 2003, 1<sup>st</sup> edition, ISBN-13: 978-0198520597.
4. Paul F. Jacobs, "Rapid Prototyping and Manufacturing: Fundamentals of Stereolithography", Society of Manufacturing Engineers in cooperation with the Computer and Automated Systems Association of SME, 1992, 1<sup>st</sup> edition, ISBN-13: 978-0872634251.

### Description and Assessment of Assignments

Each assignment will include 1-3 problems related to the corresponding lecture. The assignment may take one of the following three forms: (1) analysis problems with analytical answers, (2) analysis problems with numerical and graphical answers, or (3) writing essays or report on issues related to the corresponding lecture. These assignments will allow students to integrate the lecture and reading materials to demonstrate their knowledge. The grading rubric will follow 10 points for each assignment.

### Grading Breakdown

<b>Content</b>	<b>Points</b>	<b>% of Grade</b>
Homework	10x10=100	30
Midterm Exam	100	30
Final Presentation	100	20
Final Report	110	20
<b>TOTAL</b>		100

### **Grading Scale**

Course final grades will be determined using the following scale

A	95-100
A-	90-94
B+	87-89
B	83-86
B-	80-82
C+	77-79
C	73-76
C-	70-72
D+	67-69
D	63-66
D-	60-62
F	59 and below

### **Assignment Rubrics**

10 points for each assignment

### **Assignment Submission Policy**

The assignment should be submitted in the hand-writing paper during the class or electronic PDF via email before the deadline described in the course schedule table.

### **Grading Timeline**

The assignment will be graded and returned to the students following the course schedule table.

### **Additional Policies**

Late assignments and exam answers will not be accepted.

## Course Schedule: A Weekly Breakdown

Week	Date	Topics	Readings	HW
1	Aug 30	Finite deformation of solids I: strain tensor, stress tensor	Lecture note 1, Holzapfel Ch 2-3	HW 1 Assign
2	Sep 6	Finite deformation of Solids II: constitutive models, field equations	Lecture note 2, Holzapfel Ch 4-6	HW 2 Assign HW 1 Due
3	Sep 13	Finite deformation of Solids III: examples	Lecture note 3, Holzapfel Ch 6	HW 3 Assign HW 2 Due HW 1 Return
4	Sep 20	Introduction to polymers chains	Lecture note 4, Rubinstein Ch 2-3	HW 4 Assign HW 3 Due HW 2 Return
5	Sep 27	Polymer elasticity	Lecture note 5, Rubinstein Ch 7, Treloar Ch 3	HW 5 Assign HW 4 Due HW 3 Return
6	Oct 4	Viscoelasticity of solids	Lecture note 6	HW 6 Assign HW 5 Due HW 4 Return
7	Oct 11	Midterm exam		HW 5 Return
8	Oct 18	Fall Recess		
9	Oct 25	Mechanics of electroactive polymers	Lecture note 7	HW 7 Assign HW 6 Due
10	Nov 1	Mechanics of hydrogels	Lecture note 8	HW 8 Assign HW 7 Due HW 6 Return
11	Nov 8	Mechanics of extrusion-based 3D printing: Fused Deposit Modeling (FDM)	Lecture note 9	HW 9 Assign HW 8 Due HW 7 Return
12	Nov 15	Mechanics of photopolymerization-based 3D printing: Stereolithography (STL)	Lecture note 10, Jacobs Ch 2-4	HW 10 Assign HW 9 Due HW 8 Return
13	Nov 22	Mechanics of sintering-based 3D printing: Selective Laser Sintering (SLS)	Lecture note 11	HW 10 Due HW 9 Return
14	Nov 29	Thanksgiving Holiday		
15	Dec 6	Final Presentation		HW 10 Return
FINAL	Dec 13	Final project paper due 5 PM Dec 13 through email: qimingw@usc.edu		Date: For the date and time of the final for this class, consult the USC <i>Schedule of Classes</i> at <a href="http://classes.usc.edu/">classes.usc.edu/</a> .

## Statement on Academic Conduct and Support Systems

### Academic Conduct:

Plagiarism – presenting someone else’s ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Part B, Section 11, “Behavior Violating University Standards” [policy.usc.edu/scampus-part-b](http://policy.usc.edu/scampus-part-b). Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on scientific misconduct, [policy.usc.edu/scientific-misconduct](http://policy.usc.edu/scientific-misconduct).

### Support Systems:

*Student Health Counseling Services - (213) 740-7711 – 24/7 on call*  
[engemannshc.usc.edu/counseling](http://engemannshc.usc.edu/counseling)

Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

*National Suicide Prevention Lifeline - 1 (800) 273-8255 – 24/7 on call*  
[suicidepreventionlifeline.org](http://suicidepreventionlifeline.org)

Free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week.

*Relationship and Sexual Violence Prevention Services (RSVP) - (213) 740-4900 – 24/7 on call*  
[engemannshc.usc.edu/rsvp](http://engemannshc.usc.edu/rsvp)

Free and confidential therapy services, workshops, and training for situations related to gender-based harm.

*Office of Equity and Diversity (OED) | Title IX - (213) 740-5086*  
[equity.usc.edu](http://equity.usc.edu), [titleix.usc.edu](http://titleix.usc.edu)

Information about how to get help or help a survivor of harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants. The university prohibits discrimination or harassment based on the following protected characteristics: race, color, national origin, ancestry, religion, sex, gender, gender identity, gender expression, sexual orientation, age, physical disability, medical condition, mental disability, marital status, pregnancy, veteran status, genetic information, and any other characteristic which may be specified in applicable laws and governmental regulations.

*Bias Assessment Response and Support - (213) 740-2421*  
[studentaffairs.usc.edu/bias-assessment-response-support](http://studentaffairs.usc.edu/bias-assessment-response-support)

Avenue to report incidents of bias, hate crimes, and microaggressions for appropriate investigation and response.

*The Office of Disability Services and Programs - (213) 740-0776*  
[dsp.usc.edu](http://dsp.usc.edu)

Support and accommodations for students with disabilities. Services include assistance in providing readers/notetakers/interpreters, special accommodations for test taking needs, assistance with architectural barriers, assistive technology, and support for individual needs.

*USC Support and Advocacy - (213) 821-4710*  
[studentaffairs.usc.edu/ssa](http://studentaffairs.usc.edu/ssa)

Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

*Diversity at USC - (213) 740-2101*  
[diversity.usc.edu](http://diversity.usc.edu)

Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

*USC Emergency - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call*

[dps.usc.edu](http://dps.usc.edu), [emergency.usc.edu](http://emergency.usc.edu)

Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

*USC Department of Public Safety - UPC: (213) 740-6000, HSC: (323) 442-120 – 24/7 on call*

[dps.usc.edu](http://dps.usc.edu)

Non-emergency assistance or information.