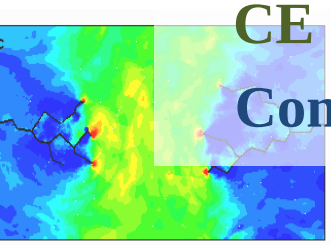
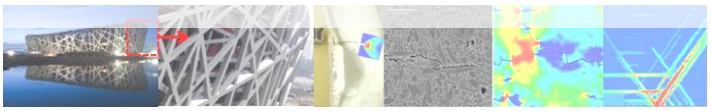
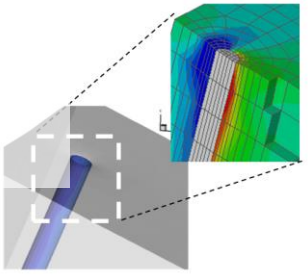
CE 597: Advanced topics in Classical and Computational Solid Mechanics (Fall 2014)

Tuesday & Thursday 9:00am-10:15am
Room: **PHYS 333**
Web site: http://engineering.purdue.edu/~zavattie/CE597/

Instructor:

Prof. Pablo Zavattieri, Office: HAMP G217, 496-9644, E-mail: zavattie@purdue.edu

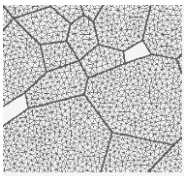
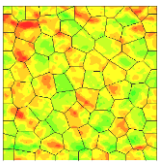
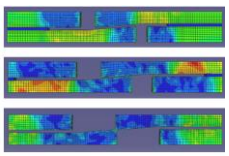
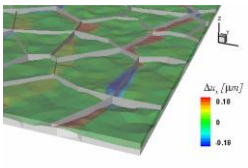
Office hours: TBD, whenever I am in my office or by appointment

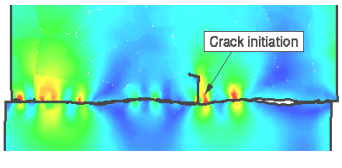
Description: This is an introductory graduate course in advanced solid mechanics for those students who are interested in learning more about fundamentals concepts of material deformation and failure modeling and current numerical techniques to solve solid mechanics problems, including nonlinear finite elements. The course is intended for students who want to improve their knowledge and background needed to solve problems using computational methods to better understand the fundamental principles on which computer simulations are based. For those who either need to develop and implement their own material constitutive models for deformation and failure or simply are interested in using commercially available finite element codes more effectively. Experimental validation will be also discussed in this course.

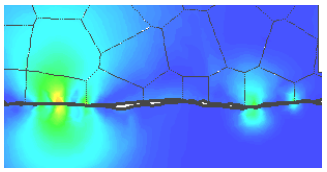
Course Objectives:

- Introduce the student to the classical solid mechanics for engineering problem-solving.
- Familiarize the student with advanced finite element methods and other numerical techniques for nonlinear modeling of material deformation and failure.
- Identify the key ingredients required to solve solid mechanics problems (e.g., what to model, geometry, initial and boundary conditions, constitutive models, failure modes and what physics must be included).
- Some topics: linear and non-linear elasticity, small strain plasticity models, hyperelasticity, viscoelasticity, fracture and failure models for material interfaces. Dimensional analysis framework and some advanced topics on dynamic and non-linear finite element algorithms.
- Example problems may include micromechanics of heterogeneous materials (e.g, polycrystalline materials, composite materials, material interfaces), interface problems and length scale bridging in deformation and damage of materials.
- Final projects may include solving solid mechanics problems that may involve the development of analytical expression, numerical tools (e.g., FEM) and even experiments in the Lyles I2I Lab (HAMP).

Students learn how to formulate and solve computational problems arising in the deformation and failure of materials at the more relevant length-scale levels, and how to experimental validate their models. Students are expected to communicate their work graphically, orally and in writing.





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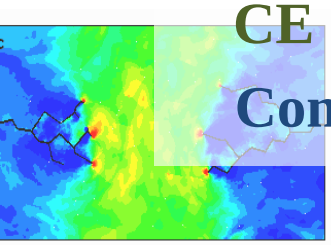
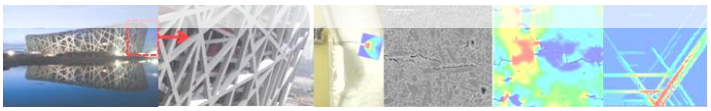
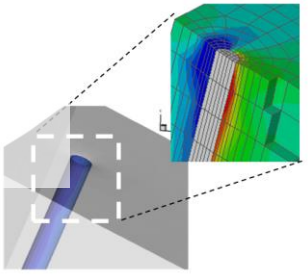




Homework: Every few lectures

Projects: Two projects (may be related)

Final Exam: Oral presentation and final report of the second project

Grading

Homework	10%
Project 1	30%
Project 2	60%

Computational modeling: We will make use of finite element codes available on campus. Demonstration of some constitutive material models will also be presented for Matlab.

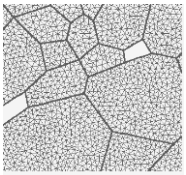
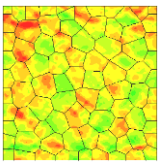
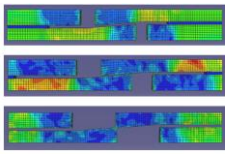
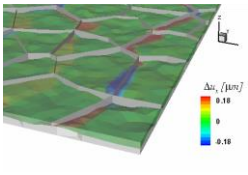
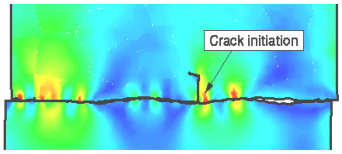
Experimental mechanics: Depending on enrollment, we will carry out some mechanical tests in the Lyles I2I Lab (HAMP).

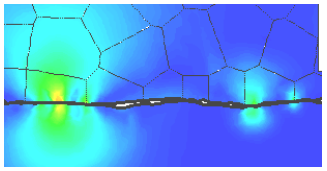
Web site: Homework, projects, exams, handouts, and grades, will be posted in the course web page: http://engineering.purdue.edu/~zavattie/CE597/

Lectures: You are responsible for taking notes during class. I will occasionally post some notes and handouts on the course web.

Books: No book is required. I will personally follow ideas from the following books and resources:

- A. F. Bower, *Applied Mechanics of Solids*, CRC Press, 2009 http://solidmechanics.org (free online)
- O.C. Zienkiewicz, R.L. Taylor, *The Finite Element Method* (Volumes 1 and 2), Sixth Edition, Elsevier, 2005.
- M. Meyers, K. Chawla, *Mechanical Behavior of Materials*, Cambridge, 2009.
- T. Belytschko, W.K. Liu, B. Moran, *Nonlinear Finite Elements for Continua and Structures*, Willey, 2001.
- Simo, J.C., Hughes, T.J.R. *Computational Inelasticity*, Interdisciplinary Applied Mathematics, Vol. 7, Springer, 2000



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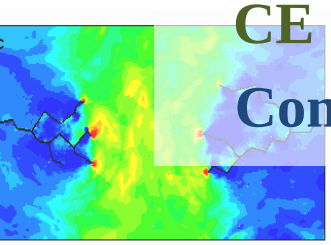
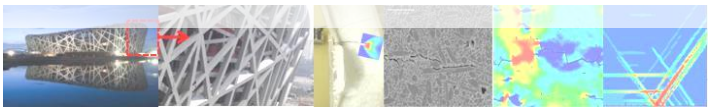
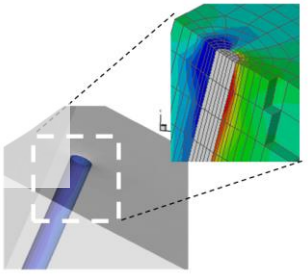
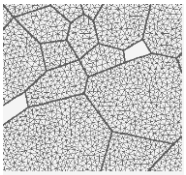
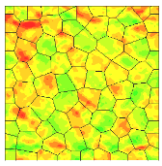
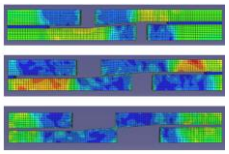
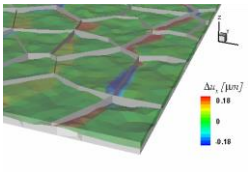
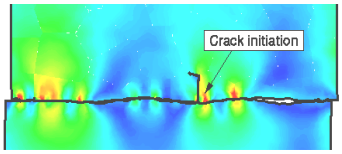




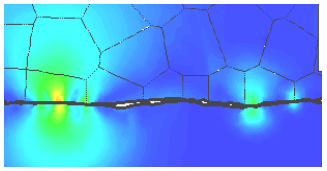
Topics to be covered in class:

This is a tentative list of topics and it is intended to be a guide for the classes.

- Introduction
- Review Vectors, Matrices, Tensors, Notation
- Displacement fields, Deformation Tensor, Definition of Strain (infinitesimal vs. large deformations)
- Internal Forces, Stress definitions
- Generalized and Principal Stress
- Equation of Motion and equilibrium
- Work, principle of Virtual work
- Constitutive Models:
    - Elasticity and anistropy
    - Hypo- and hyperleasticity
    - Poroelasticity
    - Time dependent viscoelasticity
    - Metal plasticity
    - Fracture and interfaces
- Dimensional Analysis,
- Various Aspects of the Finite Element Method and other Numerical Methods
    - Dynamic Linear Elasticity
    - Nonlinear Materials
    - Finite Element Method: Nonlinear Materials
    - Modeling Material Failure: Failure Criteria
    - Continuum approaches vs. Discrete approaches
- Other advanced topics
- Projects (theoretical/analytical, computational and experimental)

Check any update of this tentative schedule on the course web site: http://engineering.purdue.edu/~zavattie/CE597/



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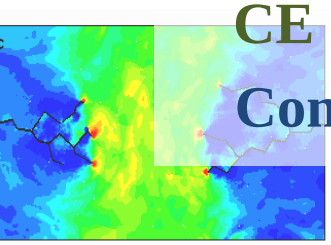
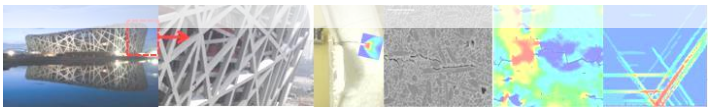
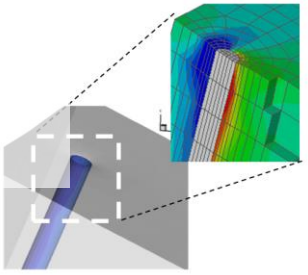




GENERAL POLICIES AND RULES

Read these rules CAREFULLY. It will be assumed that you have read this material and understood it.

Attendance

Students are expected (required) to attend and actively participate in all classes.

Academic Integrity:

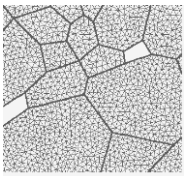
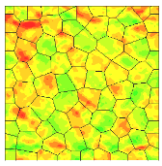
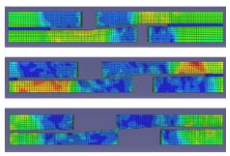
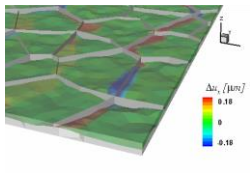
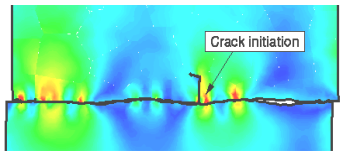
Academic integrity is expected of all students at all times. Information on what constitutes academic integrity may be found in the handbook University Regulations. Purdue prohibits "dishonesty in connection with any University activity. Cheating, plagiarism, or knowingly furnishing false information to the University are examples of dishonesty." [Part 5, Section III-B-2-a, University Regulations] Furthermore, the University Senate has stipulated that "the commitment of acts of cheating, lying, and deceit in any of their diverse forms (such as the use of substitutes for taking examinations, the use of illegal cribs, plagiarism, and copying during examinations) is dishonest and must not be tolerated. Moreover, knowingly to aid and abet, directly or indirectly, other parties in committing dishonest acts is in itself dishonest." [University Senate Document 72-18, December 15, 1972]

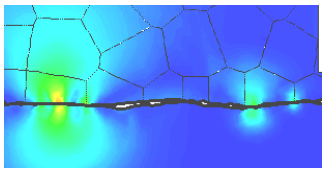
Information on what constitutes academic integrity may be found in the Purdue's student guide for academic integrity (http://www.purdue.edu/odos/aboutodos/academicintegrity.php)

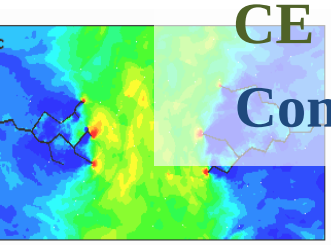
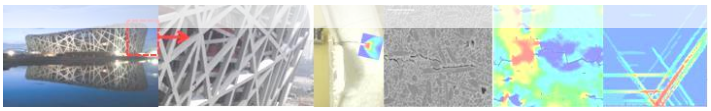
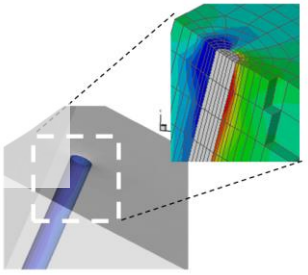
Use of Copyrighted Materials

Among the materials that may be protected by copyright law are the lectures, notes, and other material presented in class or as part of the course. Always assume the materials presented by an instructor are protected by copyright unless the instructor has stated otherwise. Students enrolled in, and authorized visitors to, Purdue University courses are permitted to take notes, which they may use for individual/group study or for other non-commercial purposes reasonably arising from enrollment in the course or the University generally.

Notes taken in class are, however, generally 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. No individual is permitted to sell or otherwise barter notes, either to other students or to any commercial concern, for a course without the express written permission of the course instructor. To obtain permission to sell or barter notes, the individual wishing to sell or barter the notes must be registered in the course or must be an approved visitor to the class. Course instructors may choose to grant or not grant such permission at their own discretion, and may require a review of the notes prior to their being sold or bartered. If they do grant such permission, they may revoke it at any time, if they so choose.



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 following website for additional information: http://www.purdue.edu/policies/pages/facilities_lands/i_2_3.shtml

Students with Disabilities

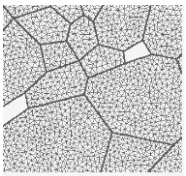
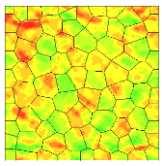
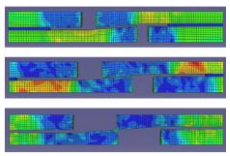
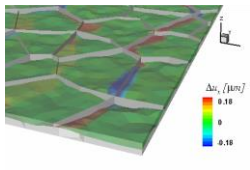
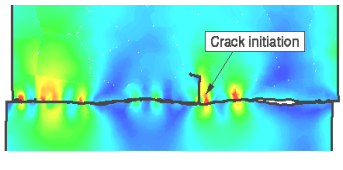
Purdue University is required to respond to the needs of the students with disabilities as outlined in both the Rehabilitation Act of 1973 and the Americans with Disabilities Act of 1990 through the provision of auxiliary aids and services that allow a student with a disability to fully access and participate in the programs, services, and activities at Purdue University. If you have a disability that requires special academic accommodation, please make an appointment to speak with me within the first three (3) weeks of the semester in order to discuss any adjustments. It is important that we talk about this at the beginning of the semester. It is the student's responsibility to notify the Disability Resource Center (http://www.purdue.edu/drc) of an impairment/condition that may require accommodations and/or classroom modifications.

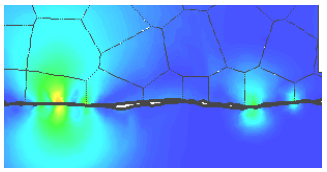
Nondiscrimination

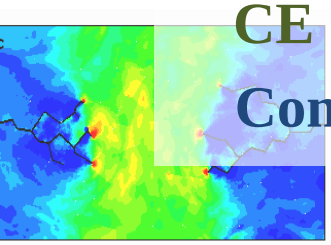
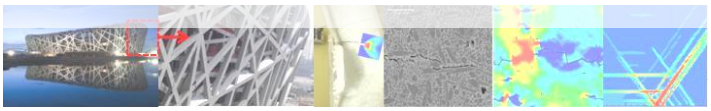
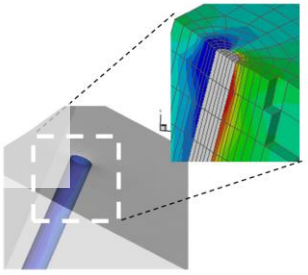
Purdue University is committed to maintaining a community which recognizes and values the inherent worth and dignity of every person; fosters tolerance, sensitivity, understanding, and mutual respect among its members; and encourages each individual to strive to reach his or her own potential. In pursuit 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 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 Executive Memorandum No. D-1, which provides specific contractual rights and remedies. Any student who believes they have been discriminated against may visit www.purdue.edu/report-hate to submit a complaint to the Office of Institutional Equity. Information may be reported anonymously.

Emergency Procedures:

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. Information will be provided via email and/or Blackboard. If a student suspects he or she may have symptoms associated with the swine flu, you are encouraged to seek medical help and not come to class. Please see Purdue's Emergency Preparedness website at



http://www.purdue.edu/emergency_preparedness/index.htm, and the Adverse Winter Weather Procedures and Announcements.

Emergency exist plans have been prepared for all classrooms located in engineering buildings. The following link provides critical information Evacuation and Shelter-in-place for our main classroom HAMP 1144: https://engineering.purdue.edu/Intranet/Groups/Administration/RPM/Safety/ClassroomEmergencyPlanning/CIVL/CIVL%201144.pdf

Here are ways to get information about changes in this course:

- Course information on Blackboard: http://www.itap.purdue.edu/tlt/blackboard/index.cfm
- Instructors' contact information: Prof. Pablo Zavattieri, (765) 496-9644, zavattie@purdue.edu
- Instructors' web pag: http://engineering.purdue.edu/~zavattie

Others

No food and absolutely no cell phones in the classroom or lab. Other electronic devices to take note (laptops and tablets) are allowed.