Solid Mechanics I
(MCEN 5023)

Mechanics of Aerospace Structures
(ASEN 5012)

Instructor: Dr. H. “Jerry” Qi

Fall, 2006

What is Solid Mechanics?

-- Mechanics is a branch of physics that is concerned with the analysis of the action of forces on matter or material systems.

-- Solid Mechanics is mechanics about deformable solids.

What do we mean "a solid"?

A solid can sustain shear.

A body is and remains CONTINUOUS under the action of external forces

- Consisting of continuous material points
- Neighboring points remain neighbors
- Neglecting its atomistic structure

Question: are the following statements right in the context of solid mechanics?

We can infinitely "zoom-in" and still see numerous material points.

A geometrical point (x,y,z) contains numerous material points.

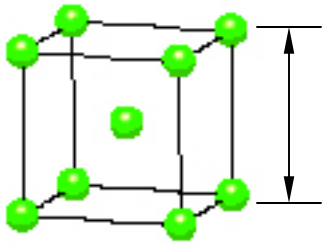
Length scales where solid mechanics is valid

Size of an atom:

Hydrogen: 0.12nm Oxygen: 0.14nm

Carbon: 0.16nm **~0.1nm**

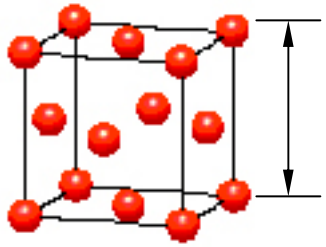
Size of lattice in crystal:



b.c.c

Iron α: a=0.286nm

Sodium: a=0.429nm



f.c.c

Aluminum: a=0.405nm

Copper: a=0.355nm

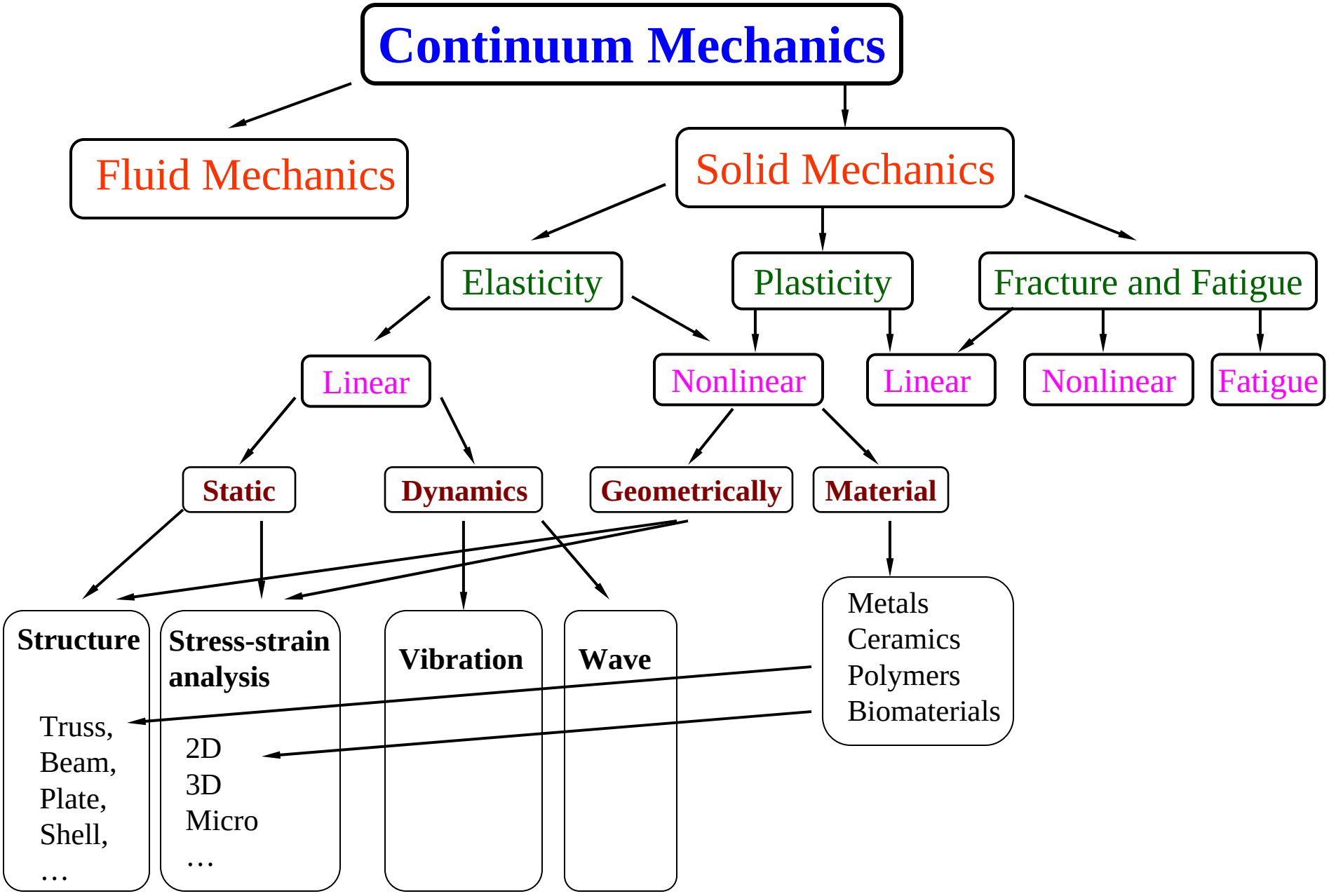
For Solid Mechanics:

>10μm, safe

>100nm, but <10μm, safe but size effect

>1nm, but <100nm, applicable in some case, but be cautious. Many arguments.

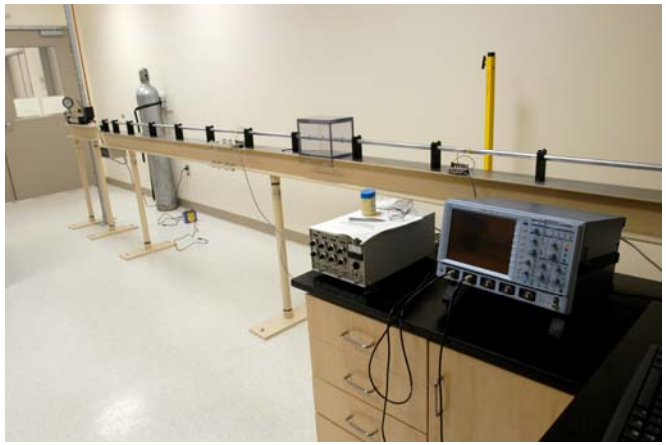
What is Solid Mechanics about?

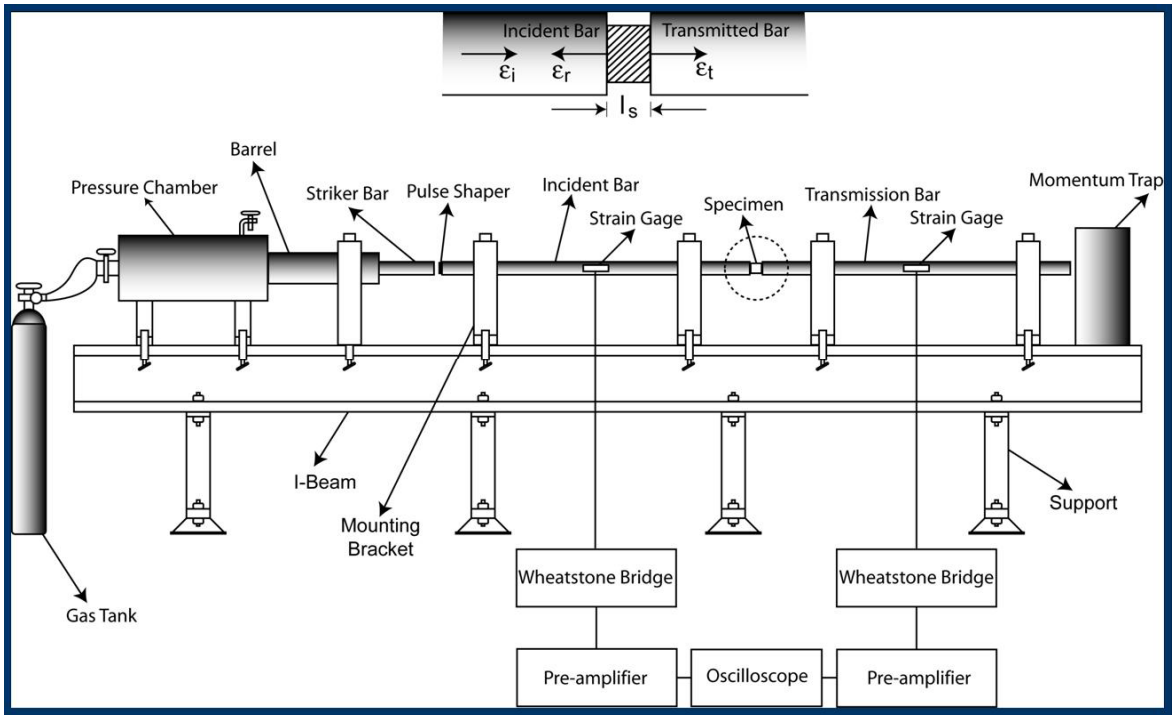


Methods in Solid Mechanics

Experiments

Strain measurements, photoelasticity,
Fatigue,
Impact,
High strain rate,
Material characterization,
….





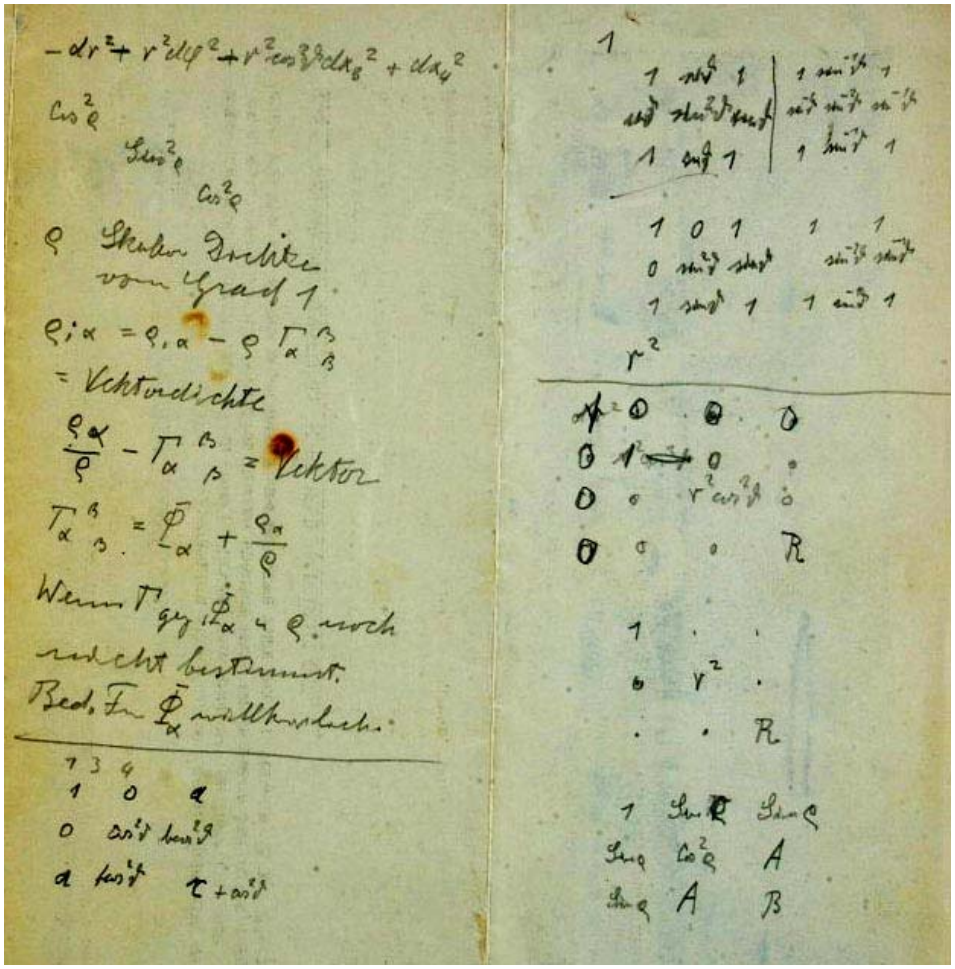
Hopkinson Split Bar High Strain Rate Test

Courtesy of A. D. Mulliken @ MIT

Methods in Solid Mechanics

Theory

Continuum mechanics,
Micromechanics,
Constitutive model,
….

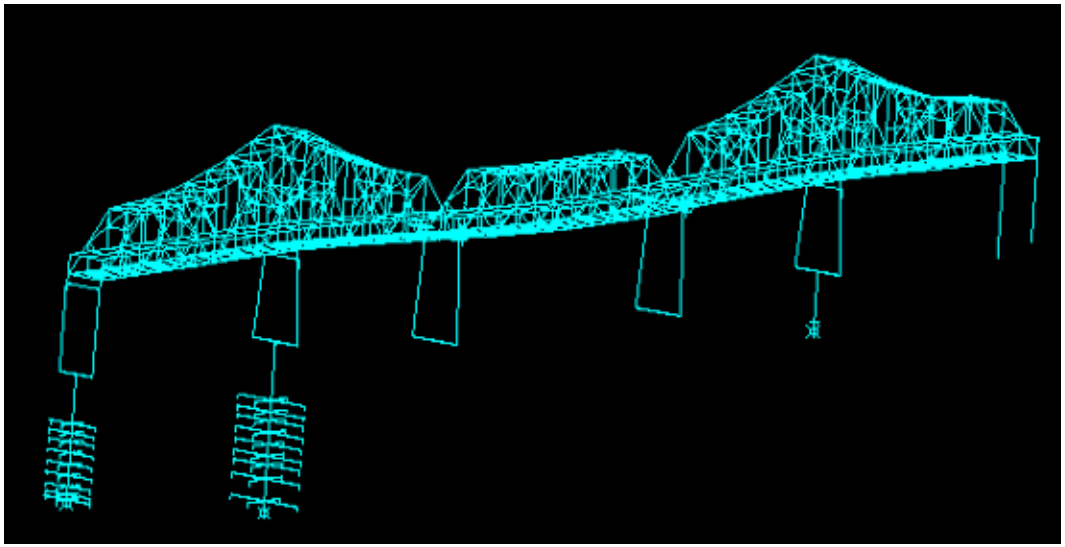


Einstein's notes on field theory & general relativity (01/01/1934), (from *Einstein Archives Online*)

Methods in Solid Mechanics

Computation

Finite element methods,
Boundary element methods,
Molecular dynamics simulations, ….



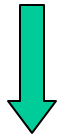
FEM simulation of the damage of San Francisco Oakland Bay Bridge caused by the 1989 Loma Prieta earthquake. (*From Adina R & D, Inc.*)

Modern solid mechanics requires a combination of experimental, theoretical, and computational mechanics

Constitutive Model

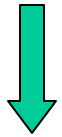
Understanding property and structure

Material mechanical property testing: *Tension/Compression, Micro-, Nano-indentation…*
Material structure characterization: *TEM, SEM, AFM, X-ray diffraction…*

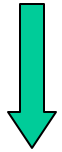


Theory development which is based on experimental observations

Continuum mechanics, micromechanics

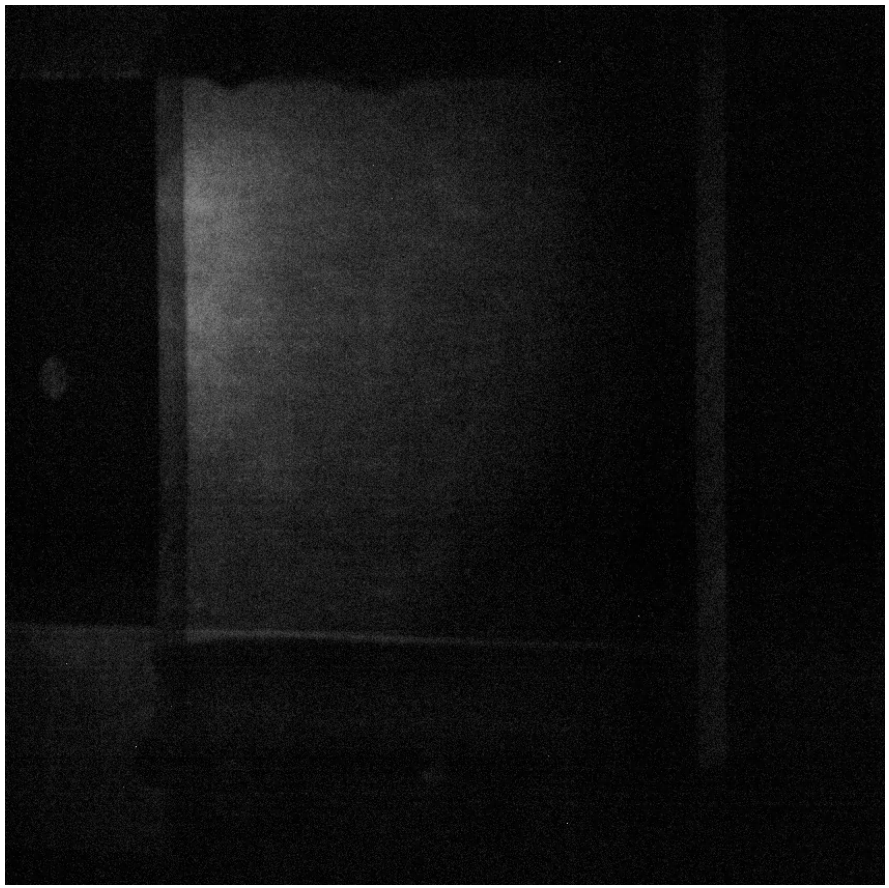


Finite element code for the model

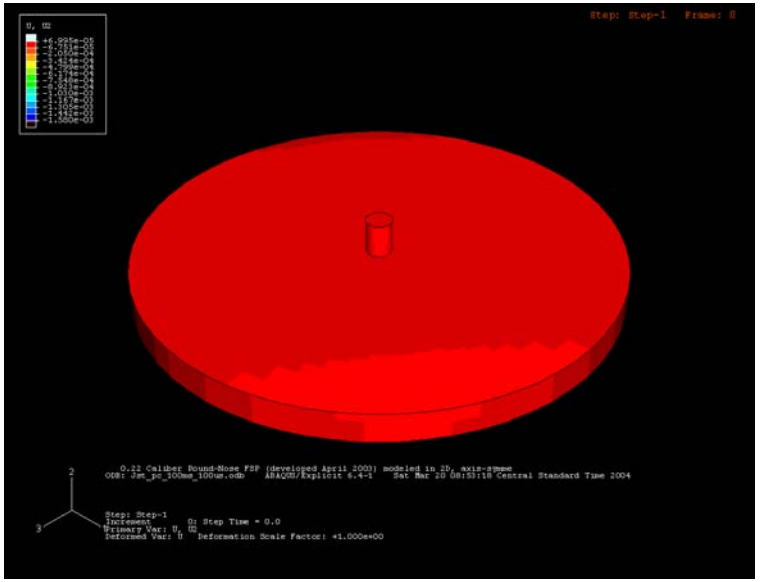


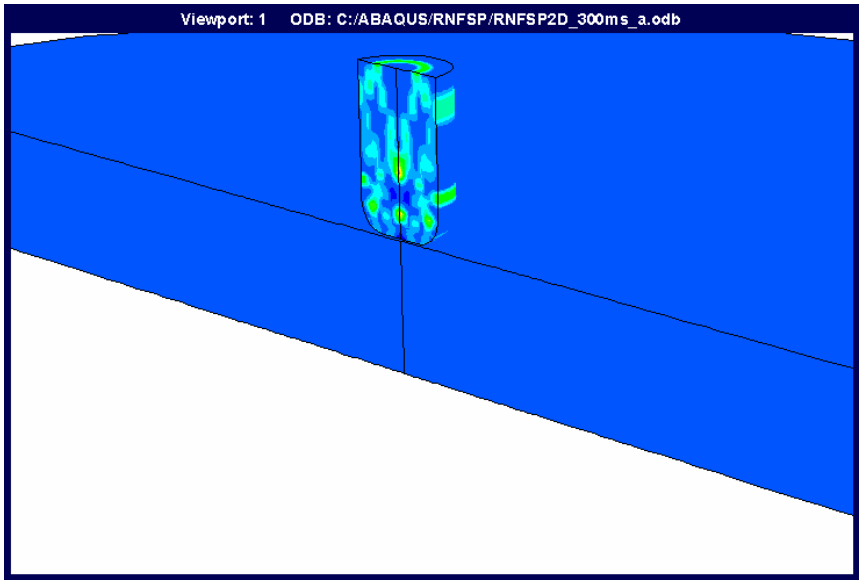
Engineering Applications

Development of Modern Solid Mechanics



PC, 500m/s

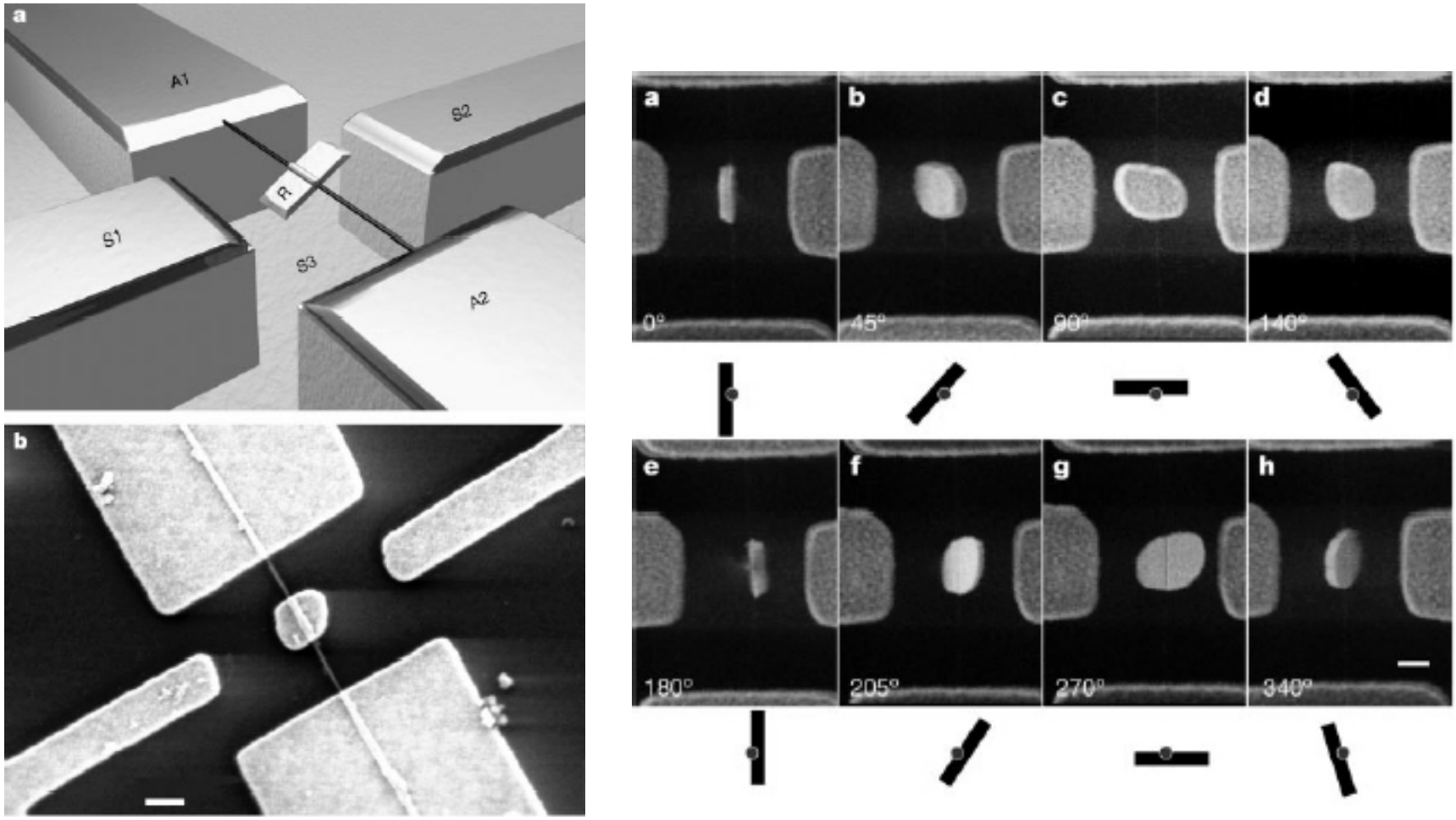




High Speed Bullet Impact

Courtesy of A. D. Mulliken, S. Sarva @ MIT

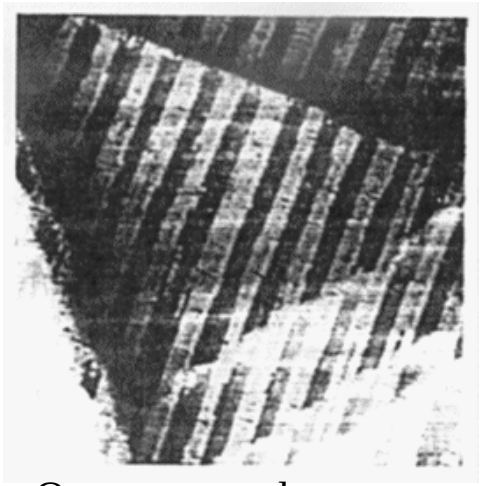
Development of Modern Solid Mechanics



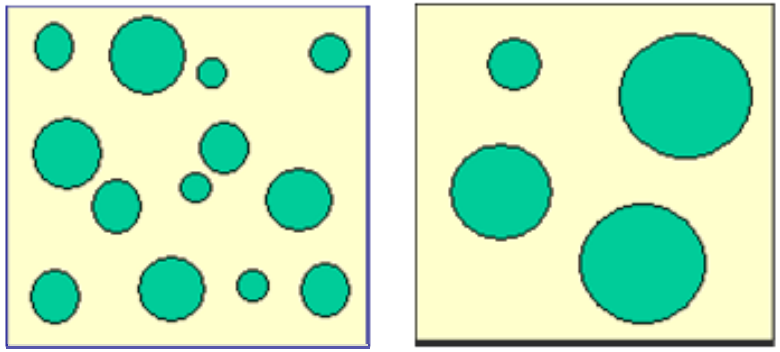
Twisting Nanotubes

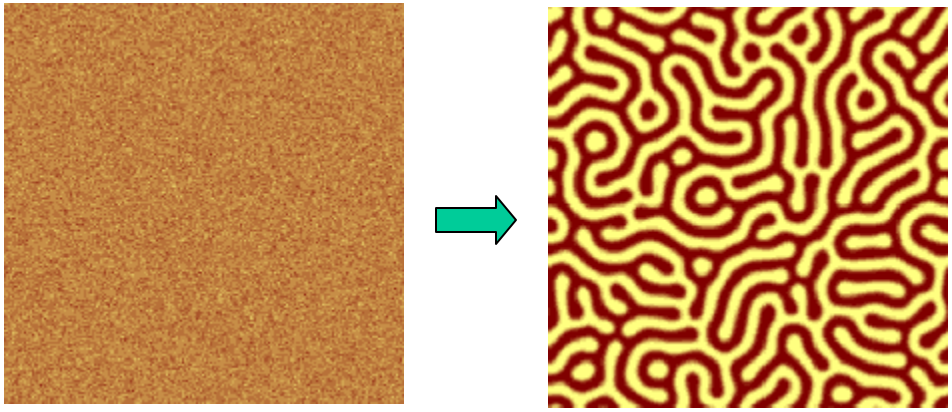
Zettl, UC Berkeley. Fennimore et al., Nature, 2003

Development of Modern Solid Mechanics



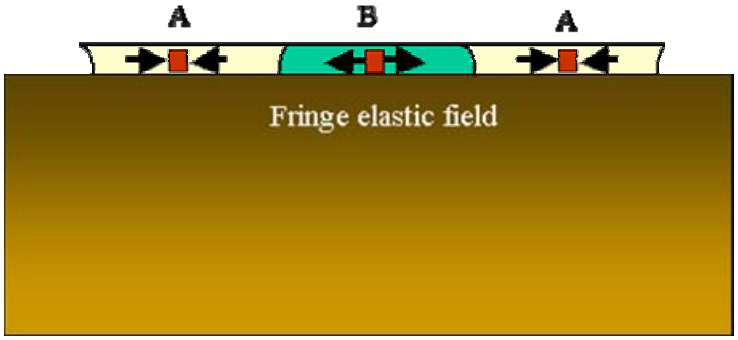
Oxygen monolayer on a copper surface





t=0s

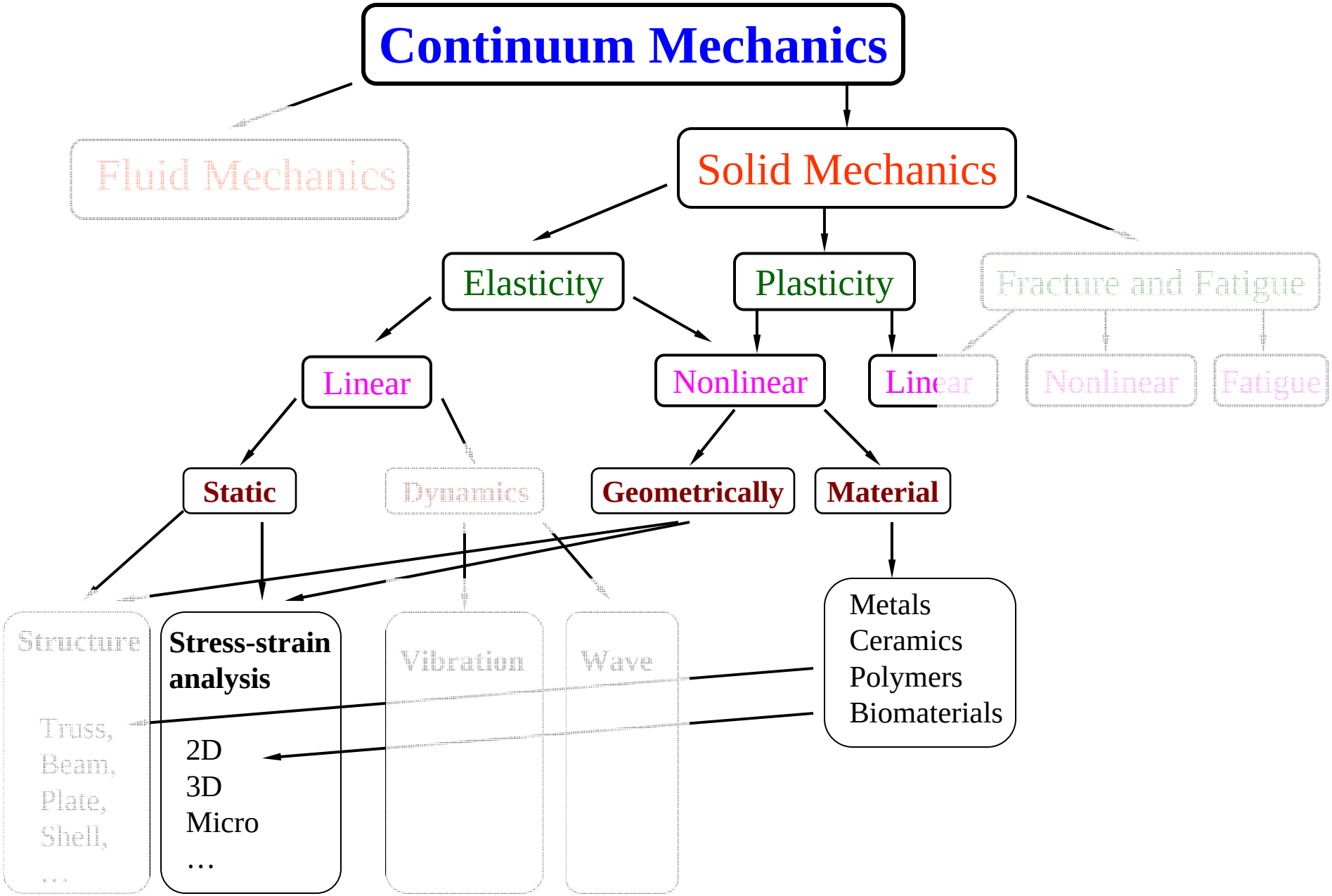
t=100000s



Self-organization nano-phase on solid surface

(W. Lu, U. Mich.)

What is this class about?



What is this class about?

Topics in this class:

- Deformation and strain measurement
- Stress and its relation to forces and moments
- Equilibrium and geometric compatibility
- Constitutive models
- Stress analysis
- Energy Methods
- Continuum mechanics
- Conservation laws
- Plasticity

Many mathematics

Few videos, and pictures

Things before we start…

Website: http://www.colorado.edu/MCEN/MCEN5023/MCEN_5023.html

Mail list: mcen5023_2006@lists.colorado.edu

How to subscribe the mail list:

Send an e-mail to listproc@lists.colorado.edu with "SUBSCRIBE MCEN5023_2006 Your Name" as the content.

Instructor

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TA

Francsico Castro
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E-mail: francisco.castro@colorado.edu

Office Hours

Instructor: WF: 4:00PM-6:00PM.
TA: W: 9-10AM

For other time, by appointment.

Things before we start…

Reference Books

Elasticity in Engineering Mechanics, 2nd edition, by Arthur R. Boresi, Ken P. Chong. Wiley Interscience Publication, New York, 2000.

Nonlinear Solid Mechanics, A Continuum Approach for Engineering, Holzapfle, G.A., John Wiley & Sons, New York, 2000.

Classical and Computational Solid Mechanics, Fung, Y.C., Tong, P., World Scientific Publishing, Singapore, 2001.

Continuum Mechanics: Concise Theory and Problems, Chadwick, P. Dover Publications,1999.

Homework:

Discussions are encouraged but your work has to be finished by you own.
Due on Wednesday before the class.

Be on time!!!

Grade:

Your final grade depends on the overall performance of the class.

Top 5% (about 3) students will receive A+.

Option B:		***Option A:***	
Homework	30%	Homework:	30%
Two mid-term exams:	30%	Two mid-term exams:	30%
A project and presentation:	30%	One two-hour final exam:	30%
Class discussion:	10%	Class discussion:	10%
Total:	100%	Total:	100%

About the project:

- 2-3 people team work.
- Any topic, but has to be related to solid mechanics.
- Abstract, presentation (15min talk+5min discussion), report.
- Presentation will be before the final exam period.
- Report due at the presentation day.
- 2-3 three evenings for presentations. Dinner will be served.
- Attendance of presentations is mandatory.

Important Days:

No Class Days:

09/04, Labor Day
11/20, 11/22, Fall Break
11/24, Thanksgiving

Exam Days:

10/06 (F), First Exam
11/03 (F), Second Exam
12/16 (Sat), Final Exam

Having a fun semester!