MAE 295: Mechanical Metamaterials
Spring Quarter 2018

Syllabus

Instructor: *Lorenzo Valdevit*
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Office hours: Tue 9.30 – 10.30 in ET444. Other times by appointment.

Class schedule: T Th 8.00 – 9.20am, DBH 1431

Textbook: No standalone textbook required.
Instructor's notes and several journal papers will be provided.

References:

Course website:

Course description: This course presents an overview of the field of mechanical metamaterials, i.e. periodic architected materials that are optimally designed to achieve combinations of mechanical properties not available in monolithic solids. We will discuss analytical and numerical modeling of mechanical properties of metamaterials (in particular stiffness, strength, toughness and wave propagation characteristics), the emergence of size effects in nano-architected materials, experimental characterization techniques, fabrication strategies (in particular additive manufacturing) and optimal design approaches (including an introduction of topology optimization).

Course Learning Outcomes. Students will: (1) appreciate the motivations for the development of mechanical metamaterials (including lattices, shell-based cellular materials and architected composite materials); (2) understand the relationships between material topology and mechanical properties in metamaterials; (3) learn how to analytically and numerically model stiffness, strength and toughness in periodic cellular materials; (4) learn how mechanical waves propagate through metamaterials and how the topology can be tuned to control wave propagation; (5) learn the analytical and numerical techniques available for optimal design of metamaterials (including topology optimization); (6) understand the origin of mechanical size effects in metamaterials with nano-scale features and strategies to exploit these effects; (7) learn the experimental characterization techniques available to probe the mechanical properties of metamaterials; (8) appreciate the manufacturing challenges related to metamaterials and learn the most common fabrication techniques.

Prerequisites: Strong graduate-level knowledge of mechanics of materials and continuum mechanics. Ability to perform basic Finite Elements simulations of mechanical properties of materials and structures using

commercial software (e.g., ABAQUS, COMSOL). Ability to write simple codes in a programming language of choice (e.g., MATLAB, FORTRAN, C++).

Lecture topics: See attached document

Grading Criteria:
Throughout the course, students will read, present and discuss journal papers, solve various modeling / optimal design assignments, prepare and deliver a final presentation on a topic of choice and take an oral final examination.

Class participation / paper discussions: 20%
Assignments: 30%
Final presentation: 20%
Final oral exam: 30%

Homework Policy:
There will be a number of homework assignments (~6) throughout the course, covering modeling and design challenges. Assignments will be posted on the website, and are typically due one week after posting.

Working together is strongly encouraged (but NOT copying each other). Identical homework assignments from two students will be considered cheating and not tolerated.

Several homework assignments will require the use of computational resources (e.g., ABAQUS, ANSYS and/or MATLAB), available in the computer labs.

These factors ALL contribute to the grade:
- Conceptually sound problem-solving approach.
- Numerical accuracy of results.
- Neatness of the presentation and description of the procedure.

Please, format your homework in a clear way. All the fundamental steps of your derivations need to be clearly stated.
A correct solution obtained with a wrong or unclear methodology will be given no credit. Conversely, numerical mistakes associated with sound and reasonable approaches will result in partial credit.

Final examination
There will be one final oral examination, approximately 30-45 minutes in length. Each student should contact the instructor to schedule her/his oral exam at a mutually convenient time (ideally during finals week, Jun 11-15, 2018).