POLITECNICO MILANO 1863

SCIENCES SORBONNE UNIVERSITÉ

UNIVERSIDAD D SEVILLA 1505

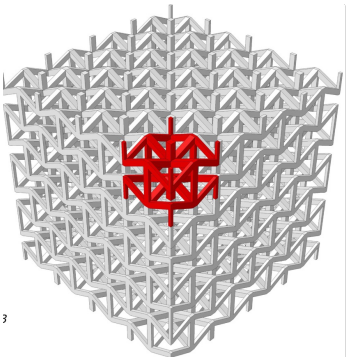
Erasmus+

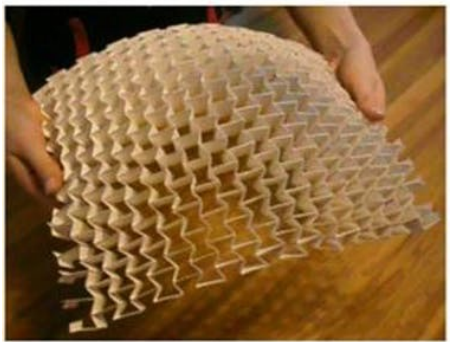
Blended intensive program

Modelling and applications of metamaterials

- 3 CFU
- 5 days at Politecnico di Milano February 24-28, 2025
- 3 Universities

A new class of materials, the so-called mechanical metamaterials, have recently taken the scene for their potential to achieve performances behond the usual ones with countless useful applications in engineering. The goal of the course is to introduce the students to some representative metamaterials, and to the specific methods for their analysis. Focus will be on auxetic and locally resonant metamaterials and to their application for shock absorption and vibration insulation. The principles of classical homogenization will be explained and applied together with numerical tools to design metamaterials.

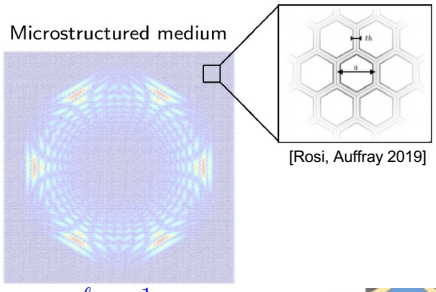




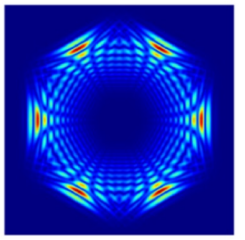
During the in-presence week at Politecnico di Milano, frontal teaching will be alternated with assisted team work.

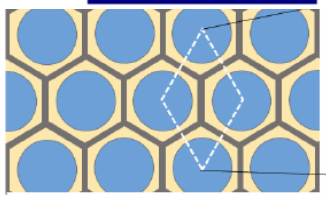
The lessons will be given by three professors, of the three institutions involved in the project.

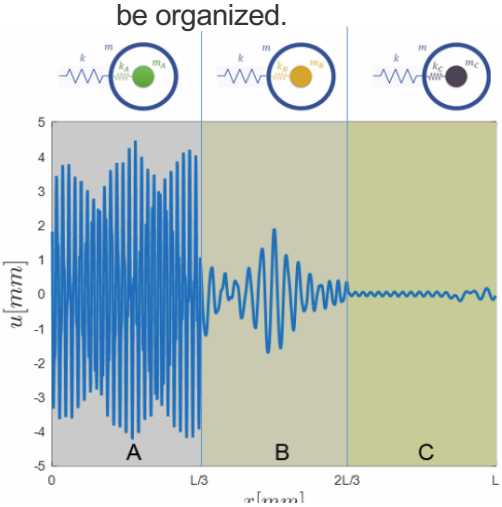
Computer laboratories will also be organized.



$$\frac{\ell}{\lambda_c} \approx \frac{1}{6}$$







Contacts

Prof. Claudia Comi (Politecnico di Milano) claudia.comi@polimi.it

Proff. Remi Cornaggia, Claire Lestringant (Sorbonne Université) remi.cornaggia@sorbonne-universite.fr, claire.lestringant@sorbonne-universite.fr

Prof. Luis Aristides Tavara Mendoza (Universidad de Sivilla) ltavara@us.es

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Erasmus+ 2021/27

Blended Intensive Programme

Title	Modelling and applications of metamaterials
Coordinating university	Politecnico di Milano
Place, Country	Milan, Italy
Coordinator at the University (name, subject area, Email)	Claudia Comi Full professor of Structural Mechanics claudia.comi@polimi.it
Type of participants targeted (students, staff)	MS and PhD students of Engineering Programs
Number of participants	40
Subject/topic of the programme	Introduction to mechanical metamaterials. Equivalent properties and homogenization of periodic materials in static: basics and applications. Metamaterials with enhanced shock absorption properties: basics and applications in industrial engineering. The design and fabrication of auxetic metamaterials: numerical analysis and 3D printing. Wave propagation in homogeneous and periodic materials (Bloch theorem, dispersion diagrams and bandgaps). Metamaterials for vibration insulation: basic principles and applications for earthquake protection of structures and infrastructures and application in industrial engineering. Higher order homogenization. Metamaterials with negative thermal expansion.
Objectives and description of the programme	The course aims at providing an up-to-date basic knowledge about auxetic metamaterials and mechanical locally resonant materials. The development of these new classes of materials offers nowadays completely new possibilities in design and control of components, structures and infrastructures.
Learning and teaching methods and expected learning/training outcomes	During the in-presence week in Milan, frontal teaching will be alternated with assisted team work. The lessons will be given by three professors, of the three institutions involved in the project. Computer laboratories will also be organized. After attending the course and after the final examination, the student will: know and understand the fields of application of locally resonant materials and auxetic materials; know the principles of homogenization of periodic materials, know the basic microscopic mechanisms responsible for the wave transmission and attenuation in metamaterials; know the more recent research trends in metamaterial design; be able to apply the above knowledge to the design and analysis of auxetic metamaterials; be able to describe and discuss the above topics with a clear and accurate language. These learning outcomes are expected to provide the student basic knowledge tools necessary for performing future activities aimed at the selection of new materials for sustainable structures and infrastructures.
Virtual component description	Before the course an on-line get-together meeting will be organized to: (1) present the objective of the course, (2) explain the structure of the course, (3) give the bibliographic reference material to be studied before the in-presence part (4) install programs. After the course the students will complete the group project (meeting on line) and will present it for the final evaluation during an on-line session.

Virtual component duration (timing, dates and nr of hours)*	Before: February 17: 2 hours – in streaming After: March 7: 4 hours – project presentation in streaming March 14: 4 hours – project presentation in streaming
Field of education targeted (students)	Civil, Mechanical, Aerospace, Material, Electronical Engineering or related Engineering.
Education level targeted (students)	Master level and PhD level.
Start and end date of the physical activity	February 24 to February 28 5 days, about 6 hours per day
Number of ECTS credits awarded (min. 3 ECTS credits)	3
Main teaching/training language	English
City of the venue	Milan

*before, after, in the meanwhile

Partner	*Country*	*Number of students participating & number of days per participant*	*Number of teaching staff & number of days per staff member*
Sorbonne Université	France	15 students – 5 days	1 professor – 5 days
Universidad de Sivilla	Spain	15 students – 5 days	1 professor – 5 days