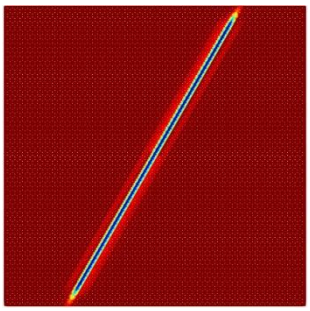
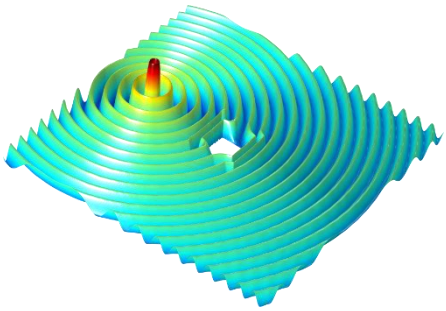
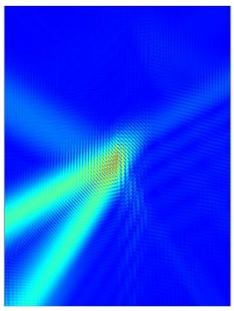
UNIVERSITY OF CAGLIARI & UNIVERSITY OF TRIESTE

present

Online PhD Course

Introduction to Mechanical Metamaterials

Lecturers
Michele Brun, DIMCM, University of Cagliari
Giorgio Carta, DIMCM, University of Cagliari
Massimiliano Gei, DIA, University of Trieste

Hours: 20

Starting date: 21 September 2026

Abstract
Mechanical metamaterials are artificially engineered media whose effective properties arise primarily from their internal architecture rather than from their constituent materials. By tailoring their microstructure, these media can exhibit extraordinary mechanical behaviors that are difficult or impossible to achieve with conventional materials found in nature, including wave filtering, vibration attenuation, negative effective properties and programmable responses.

This course provides an introduction to the theoretical foundations and computational tools for the analysis and design of mechanical metamaterials based on periodic architectures. Following a general overview of the field, the course will focus on the dynamics of periodic systems, considering both discrete models (e.g., mass–spring lattices) and continuous structures (such as rods and beams). Particular emphasis will be placed on wave propagation phenomena, dispersion analysis and band-gap formation.

Building on these concepts, participants will learn how the principles governing phononic crystals and locally resonant metamaterials can be exploited to design structures with tailored dynamic properties for vibration control, impact mitigation and wave manipulation. Numerical examples and practical sessions will illustrate the implementation of the theoretical methods and demonstrate their application to representative engineering problems.

The course is intended for PhD students in civil and mechanical engineering, applied mathematics, physics and related disciplines, as well as academic and industrial researchers interested in advanced topics in structural dynamics and wave physics. A basic background in solid and structural mechanics is recommended. Familiarity with a scientific computing software, such as *MATLAB* or *Mathematica*, will be beneficial for the hands-on computational sessions.

Schedule

First week (morning lectures)

21/09/2026, 3 hrs, **23/09/2026**, 3 hrs, **25/09/2026**, 3 hrs

Introduction to mechanical metamaterials, finite discrete systems, periodic discrete systems (Floquet-Bloch technique), Laboratory session on discrete systems.

Second and third week (morning lectures)

28/09/2026, 3 hrs, **30/09/2026**, 3 hrs, **02/10/2026**, 3 hrs, **05/10/2026**, 2 hrs

Finite continuous systems (rods and beams), periodic continuous systems, application to a real bridge, transfer and scattering matrices, Laboratory session on continuous systems.

Enrolment

The course is free, but access is restricted to participants that register up to **11 September 2026** (by sending an email to the lecturers). Links to the online platform (MS Teams) will be sent to registered participants. Notes and slides will be made available to participants.

Contacts

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References

Textbooks:

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[2] Graff K.F., "Wave Motion in Elastic Solids", Second Edition, Dover Publications, Inc., New York, 1991.

Selected papers:

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[4] Brun M., Guenneau S. and Movchan A.B., "Achieving control of in-plane elastic waves", *Applied Physics Letters* **94**, 061903, 2009.

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[8] Carta G. and Brun M., "Bloch-Floquet waves in flexural systems with continuous and discrete elements", *Mechanics of Materials* **87**, 11-26, 2015.

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[10] Carta G., Jones I.S., Movchan N.V., Movchan A.B. and Nieves M.J., "'Deflecting elastic prism' and unidirectional localisation for waves in chiral elastic systems", *Scientific Reports* **7**, 26, 2017.

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[14] Carta G., Nieves M.J. and Brun M., "Forcing the silence of the Lamb waves: Uni-directional propagation in structured gyro-elastic strips and networks", *European Journal of Mechanics A/Solids* **101**, 105070, 2023.

[15] Carta G., Salis A. and Meloni D., "Modelling bridges and pipelines as periodic Timoshenko–Ehrenfest beams", *International Journal of Solids and Structures* **332**, 113945, 2026.

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