

# Introduction to Metamaterials and Artificial Materials for Advanced Electromagnetic, Mechanical, and Civil Engineering Applications

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SSD: ING-INF/02 – Campi Elettromagnetici

Università Niccolò Cusano



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10:30-12:30

Room: Ingegneria 3

Università Niccolò Cusano

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### Abstract

Metamaterials are artificial media exhibiting advantageous and unconventional physical/mechanical properties that cannot be readily found in nature. These artificial materials are composed of a micro-scale engineered arrangement of structural elements that, albeit being made of conventional materials, lead to unusual material responses. They have a foundation in electromagnetics but have recently found wide innovative applications in several engineering mechanics/civil/acoustics/electrodynamics disciplines. The course aims at providing the fundamentals of metamaterials theory and concepts, along with an overview of the most appealing/emerging applications in advanced engineering fields.

### Course Topics

PART 1: Fundamental concepts of metamaterial and artificial media

- History of metamaterials and early artificial media research
- Fundamentals and basic theory/concepts of multiphysics metamaterials
- Volumetric and surface metamaterials (i.e., metasurfaces), soft/hard surfaces, periodic and quasi-periodic surfaces

PART 2: Analysis and synthesis of materials and artificial media

- Advanced modelling and simulation techniques for the analysis of periodic and quasi-periodic structures with a focus on Floquet modes theory
- Advanced design techniques for the synthesis of innovative metamaterials in engineering fields

PART 3: Innovative applications of metamaterials and advanced engineering

- Design and applicative examples of metamaterials regarding specific engineering applications in mechanics/civil/acoustics/electrodynamics and brief notes to multi-physics metamaterials

At the end of the course a final written exam is expected.

Short Curriculum Vitae

Stefano Vellucci received the B.S. and M.S. degrees (summa cum laude) in electronic engineering, and the Ph.D. degree in applied electronics from ROMA TRE University, Rome, Italy, in 2012, 2015, and 2019, respectively. He is currently a Research Fellow and Lecturer in two courses in electromagnetic fields at Niccolò Cusano University, Rome, Italy.

Previously he acquired skills in the field of industrial research working at MBDA, Missile Systems, and as Antenna Engineer at ELT Elettronica S.p.A. He has been also a Post-Doctoral Researcher with ELEDIA Research Center, University of Trento, Italy, involved in the study and development of metasurfaces for space and terrestrial applications, and a Post-Doctoral Researcher with the Department of Industrial, Electronic, and Mechanical Engineering, at ROMA TRE University, involved in the development of models and design techniques of reconfigurable metasurfaces for applications in the field of new intelligent antenna systems.

His current research interests include the design and applications of artificially engineered materials and metamaterials to RF and microwave components, non-linear and reconfigurable circuit-loaded metasurfaces for radiating structures, analysis, and design of metasurface-based cloaking devices for antennas. He has been a Guest Editor of three journal special issues focused on microwave, photonic, and mechanical metamaterials and is a member of the Virtual Institute for Artificial Electromagnetic Materials and Metamaterials (METAMORPHOSE VI). His research activity has been recognized through national and international awards, including the URSI Young Scientist Award (2022), the IEEE Antennas and Propagation Society Student Award of the Central-Southern Italy Chapter (2019), and the Leonardo-Finmeccanica Innovation Award for “Young Students” (2015).