

## TIME TABLE

| TIME          | Monday           | Tuesday         | Wednesday       | Thursday        | Friday          |
|---------------|------------------|-----------------|-----------------|-----------------|-----------------|
|               | <b>April 26</b>  | <b>April 27</b> | <b>April 28</b> | <b>April 29</b> | <b>April 30</b> |
| 09.00 - 09.45 | Registration     | Castellano      | De Almeida      | Raze            | Dion            |
| 09.45 - 10.30 | Lo Feudo         | Castellano      | De Almeida      | Dion            | Dion            |
| 11.00 - 11.45 | Castellano       | De Almeida      | De Almeida      | Dion            | Vaiana          |
| 11.45 - 12.30 | Castellano       | De Almeida      | Raze            | Dion            | Vaiana          |
| 14.00 - 14.45 | Castellano       | Lo Feudo        | Raze            | Dion            |                 |
| 14.45 - 15.30 | Lo Feudo         | Lo Feudo        | Raze            | Vaiana          |                 |
| 16.00 - 16.45 | Lo Feudo         | Poster Session  | Raze            | Vaiana          |                 |
| 16.45 - 17.30 | Lo Feudo         | Poster Session  | Vaiana          | Vaiana          |                 |
|               | welcome aperitif |                 | social dinner   |                 |                 |

## ADMISSION AND ACCOMMODATION

The course is offered in a hybrid format, allowing participants the flexibility to attend either in person or remotely via the Microsoft Teams platform. Admission to on-site attendance is granted on a first-come, first-served basis to comply with the capacity of the lecture room.

### Registration fees:

- **Early Bird On-Site Participation: € 650.00 + VAT\***

Deadline: February 26, 2027

- **Late On-Site Participation: € 800.00 + VAT\***

Deadline: April 14, 2027

- **Live Streaming Online Participation: € 250.00 + VAT\***

Deadline: April 14, 2027

On-site participation includes a complimentary bag, five fixed menu buffet lunches, hot beverages, downloadable lecture notes.

Online participation includes downloadable lecture notes.

Application forms should be submitted online through the website: <http://www.cism.it>. A confirmation message will be sent to participants whose applications are accepted.

Upon request, and subject to availability, a limited number of on-site participants can be accommodated at the CISM Guest House for € 35 per person per night. To request accommodation, please contact: [foresteria@cism.it](mailto:foresteria@cism.it)

\* where applicable; bank charges are not included - Italian VAT is 22%.

## CANCELLATION POLICY

Applicants may cancel their registration and receive a full refund by notifying the CISM Secretariat in writing (via email) no later than:

- February 26, 2027, for early bird on-site participation;
- March 14, 2027, for late on-site participation;
- April 14, 2027, for online participation.

No refunds after the deadlines. Cancellation requests received before these deadlines and incorrect payments will be subject to a € 50.00 handling fee.

## CISM GRANTS

A limited number of participants from universities and research centers who do not receive support from their institutions can request a waiver of the registration fee and/or free lodging.

Requests must be submitted via the CISM website by **February 26, 2027**. Applicants should select the relevant option in the online application form and provide a curriculum vitae and a letter of recommendation from their department head or supervisor confirming that their institution is unable to provide financial support. Preference will be given to applicants from countries that sponsor CISM.

For further information please contact:

CISM (Seat of the course)  
Palazzo del Torso - Piazza Garibaldi 18 - 33100 Udine (Italy)  
tel. +39 0432 248511 (6 lines)  
e-mail: [info@cism.it](mailto:info@cism.it) | [www.cism.it](http://www.cism.it)



# EXPERIMENTAL VIBRATION TESTING FOR NONLINEAR SYSTEM IDENTIFICATION

CISM Advanced School  
coordinated by

**Stefania Lo Feudo**  
ISAE-SUPMECA, Saint-Ouen, France

**Nicolò Vaiana**  
University of Naples Federico II, Italy

**Udine April 26 - 30 2027**

## EXPERIMENTAL VIBRATION TESTING FOR NONLINEAR SYSTEM IDENTIFICATION

The CISM Advanced Course on Experimental Vibration Testing for Nonlinear System Identification aims to provide doctoral students and researchers from academia and industry with cutting-edge knowledge for the dynamic characterization of nonlinear structural and mechanical systems. Although mechanical vibrations are a common topic in engineering curricula, they are usually presented from theoretical and numerical perspectives, while experimental aspects are often briefly covered and limited to the linear domain. In contrast, engineering and industrial systems exhibit nonlinear behavior due to material and geometric effects, contact, and damage, leading to complex dynamic responses, including amplitude-dependent resonances, jumps, hysteresis, and chaotic behavior.

This course aims to bridge this

gap by presenting state-of-the-art experimental methods and recent research advances in vibration testing of nonlinear systems, combining classical testing and linear signal processing with modern measurement and identification techniques. Advanced sensing technologies, including radar interferometry, nonlinear ultrasonics, optical fibers and video analysis, are introduced together with recent tools for measuring and identifying nonlinear responses. These include experimental continuation for tracking solution branches, as well as data assimilation and AI-based methods such as physics-informed neural networks.

The first topic of the course addresses the vibrational response of structures. Participants will be introduced to the fundamentals of Operational Modal Analysis, signal processing, and Computer Vision

applied to structural vibrations. The lectures will further explore structural response under seismic loading, nonlinear vibration phenomena, and hysteretic behavior.

The second topic focuses on advanced sensing and measurement technologies for structural dynamics. Both non-contact techniques, such as radar interferometry, nonlinear ultrasonics, and camera-based measurements, and minimally invasive contact sensors, including fiber optic and motion capture systems, will be presented. Their principles will be illustrated through experimental applications on real-world and large-scale nonlinear structures.

The third part addresses experimental methods for nonlinear dynamical systems. It explores vibration testing for systems exhibiting strong nonlinearities, with particular emphasis on contact dynamics

and hysteresis. Recent developments in experimental continuation methods and signal processing techniques for diagnostics will be detailed. Testing procedures for hysteretic devices will also be presented.

The fourth topic focuses on parameter identification and model updating. It covers dynamic damage identification, hysteretic model formulation, parameter identification, data assimilation, and model calibration for seismic response. Advanced computational tools, including finite element model updating and physics-informed neural networks, will be introduced to support nonlinear analysis and predictive modeling.

Some practical sessions with programming exercises will complement the lectures. A poster session will be held on the afternoon of the second day.

## PRELIMINARY SUGGESTED READINGS

Almeida, J. Pacheco de, and Hout, R. (2026). Guest editorial: Advances on modelling and design of RC structural wall systems. Blind prediction and postdiction simulations of U-shaped wall tests, *Bull. Earthq. Eng.*, 24.1: 1-8.

Camassa, D., Castellano, A., et al., (2025). A novel mode shape identification approach for structures having planes with rigid-like behavior. *J. Sound Vib.*, 594, 118689.

Lo Feudo, S., Han, Y., et al. (2025). Video tracking of targets for vibration measurement of large-scale structures under seismic excitation, *Earthq Eng Struct Dyn*, 54: 2106-2120.

Raze, G., Abeloos, G., Kerschen, G. (2025). Experimental continuation in nonlinear dynamics: recent advances and future challenges, *Nonlinear Dyn* 113(6): 4949–4997.

De Domenico, D., Losanno, D.,

Vaiana, N. (2023). Experimental tests and numerical modeling of full-scale unbonded fiber reinforced elastomeric isolators (UFREIs) under bidirectional excitation, *Eng Struct* 274: 115118.

Lo Feudo, S., Dion, J-L., et al., (2023). Video analysis of nonlinear systems with extended Kalman filtering for modal identification. *Nonlinear Dyn* 111: 13263–13277.

Vaiana, N., Rosati, L. (2023). Analytical and differential reformulations of the Vaiana-Rosati model for complex rate-independent mechanical hysteresis phenomena, *Mech Syst Sig Process* 199: 110448.

Castellano, A., Camassa, D., Fraddosio, et al. (2021). Dynamic damage identification for a full-scale parabolic tuff barrel vault under differential settlements of the supports. *Constr Build Mater* 291:123271.

## INVITED LECTURERS

**Anna Castellano** - Polytechnic University of Bari, Italy  
*5 lectures on:* radar interferometry for dynamic identification of civil and industrial structures. Operational Modal Analysis; dynamic damage identification; nonlinear ultrasonic techniques for damage detection of materials and for SHM of structures.

**Jean-Luc Dion** - ISAE-SUPMECA, Saint-Ouen, France  
*6 lectures on:* linear and nonlinear dynamic diagnostics. Signals spectral and statistical properties; window functions and time-frequency tools; contact dynamics; linear analysis of nonlinear systems; data assimilation techniques for parametric identification.

**Stefania Lo Feudo** - ISAE-SUPMECA, Saint-Ouen, France  
*6 lectures on:* Computer Vision tools for experimental nonlinear vibration analysis. Camera basics; fundamentals of image processing; discrete point tracking and full-field measurements; application to nonlinear vibrating structures; 3D motion reconstruction in stereo-vision.

**João Pacheco de Almeida** - Université Catholique de Louvain, Belgium  
*5 lectures on:* parameter identification from experimental seismic response. Nonlinear response-history analysis; motion capture and fiber optic sensing; model calibration; physics-informed surrogate modelling; nonlinear finite element model updating.

**Ghislain Raze** - University of Liège, Belgium  
*5 lectures on:* nonlinear vibration testing and experimental continuation. Basics of nonlinear vibrations and nonlinear vibration testing; principles of continuation; non-invasive stabilizing control; phase-locked loops; Control-Based Continuation.

**Nicolò Vaiana** - University of Naples Federico II, Italy  
*6 lectures on:* experimental and computational analysis of hysteretic systems. Hysteresis phenomena and devices; experimental characterization: uniaxial and biaxial tests; hysteretic models: formulation and parameter identification; numerical simulations.

## LECTURES

All lectures will be given in English.  
Lecture notes can be downloaded from the CISM web site.  
Instructions will be sent to accepted participants.