Dottorato di Ricerca di Interesse Nazionale

Defense against natural risks and ecological transition of built environment

PhD School 2023

Courses descriptions

Fundamentals of Risk Analysis

Instructors:
Prof. Carmine Galasso Institute for Risk and Disaster Reduction, London
Prof. Fabrizio Paolacci, Dipartimento di Ingegneria civile, informatica e delle tecnologie aeronautiche, Univ. Roma3

Hours:
24

Curriculum:
All

Year
I

Final examination
Yes

Short description:
The course aims at introducing the students to the risk analysis. This basic course will allow students to manage the main tools of reliability and probabilistic risk analysis. In particular, after a brief introduction to the fundamentals of probability theory, the reliability analysis of structures will be described, and the main methodologies and tools will be shortly presented (reliability index, FORM, SORM, sampling methods, etc..). Moreover, the Probabilistic Risk Analysis methods will be formulated for both components and entire systems, which includes Fragility analysis, Risk Assessment methods and Catastrophe risk analysis. Some illustrative examples will finally proposed and commented.

Programme

RISK1. Fundamentals of Probability Theory – 5 hours – prof. C. Galasso

a. Probability and stochastic processes
    i. Elements of probability (conditional probability, random variables and functions, moments, probability functions
    ii. Regression and correlation analysis
    iii. Statistical Inference from data
    iv. Bayesian analysis

RISK2. Reliability Analysis of structures – 5 hours – prof. F. Paolacci

a. Structural performance and Limit States
b. Margin of Safety and Safety Factor
c. Probability of failure and Reliability: reliability index
d. First and Second Order Reliability methods: FORM and SORM methods
e. Sampling methods
f. Components and system failure

RISK3. Probabilistic Risk Analysis (PRA) - 6 hours – prof. C. Galasso

a. Mathematical Formulation of the problem (total probability theorem)
b. Fundamentals of Catastrophe (CAT) risk modelling
    i. Decomposition of risk: hazard, vulnerability, exposure
c. Limitations of current CAT risk modelling approaches
d. Modelling, quantifying tomorrow's risk from natural hazard
    i. Quantifying earthquake risk and the potential benefits of risk-mitigation strategies on present and future losses in Kathmandu Valley (KV), Nepal
    ii. Quantifying flood risk and the potential benefits of risk-mitigation strategies on present and future losses in Kathmandu Valley (KV), Nepal
e. Accounting for multi-hazard interactions in risk models

RISK4. Probabilistic Risk Analysis (PRA) - 10 hours – prof. F. Paolacci

a. Natural hazards and their probabilistic mathematical formulation
    i. An introduction to Probabilistic Seismic Hazard Analysis
b. Vulnerability and Risk analysis of structures and components
    i. Fragility analysis
        1. Methods for deriving Fragility functions
        2. Definition of Low and High-fidelity models for fragility analysis
        3. Definition of limit states
        4. Case Studies (RC Frame, Steel Frame)
    ii. Risk Analysis
        1. Qualitative Risk Assessment methods (Index methods)
        2. Quantitative Risk Assessment methods
            a. Selection of the decision variables (Economic losses, Population risk)
        3. Probabilistic Risk analysis under natural hazards
            a. Probabilistic seismic Risk analysis
    iii. Illustrative examples

Final Exam

Students will be asked to solve some exercises on fundamentals of reliability and risk analysis.

Suggested Readings

Seismic Reliability Analysis of Structures Hardcover – December 1, 2004
by P. E. Pinto, R. Giannini, P. Franchin, IUSS Press (Editor)

Nonlinear Computational Mechanics (Fluid and Solids)

Instructors:
Prof. Gabriele Freni, Ingeneria Civile e Amientale, Universotà KORE, Enna
Prof. Mauro De Marchis, , Ingeneria Civile e Amientale, Universotà KORE, Enna
Prof. Giovanni Garcea, Dipartimento di Ingegneria Informatica, Modellistica, Elettronica e Sistemistica, Università della Calabria
Prof. Leopoldo Greco, Dipartimento di Ingegneria Civile e Architettura, Università di Catania
Prof. Massimo Cuomo, Dipartimento di Ingegneria Civile e Architettura, Università di Catania

Hours:
27

Curriculum:
All

Year
I

Final examination
Yes

Short description:
The aim of the course is to give the students a basic introduction for the non-linear analysis of mechanical systems. Classes involve both theoretical lessons and practical applications with appropriate numerical codes. The first part (CM1-CM4) is dedicated to the basis of continuum solid mechanics, and to solution methods. The second part (CM5–CM9) is dedicated to Computational Fluid Dynamics. Fluid-Structure Interaction will be treated in an advanced course. The last part of the course, devoted to structural models, will be offered in a seminar format and will not be part of the final examination.

Programme

Computational Solid Mechanics. General Background – prof. M. Cuomo e L. Greco

CM1. Elements of Nonlinear Continuum Mechanics (3h)
CM2. Weak form for 1D example (2h)
CM3. Lagrangian formulations of FE (3h)

Computational Solid Mechanics. Solution methods – prof. G. Garcea

CM4. Continuation methods and perturbation methods (6h)

Computational Fluid Dynamics - prof. G. Freni e M. De Marchis

CM5. Fundamental Equations in CFD (2h)
CM6. Domains, meshes and practical applications (2h)
CM7. A critical discussion on numerical methods, convergence problems and stability (2h)
CM8. Examples and case studies on Environmental Applications and Natural Risks analysis (2h)
CM9. Model calibration and uncertainty evaluation (3h)

Suggested readings

[1] T. Belitschko, W.K. Liu, B. Moran, *Nonlinear Finite Elements for Continua and Structures*, Wiley, 2000.

Nonlinear Oscillations and Perturbation Methods

Instructor:
Prof. Daniele Zulli, Università degli Studi dell'Aquila

Hours:
15

Curriculum:
All

Year:
I

Final examination
Yes

Short description:
This course introduces the phenomena associated with nonlinear oscillations and the use of asymptotic techniques for evaluating the response of one- or more- degree-of-freedom oscillators. Preliminarily, the fundamentals of perturbation methods are described, starting with applications on algebraic systems and then proceeding to differential systems with one- or more-d.o.f. Then the study of the free and forced oscillations of a one-degree-of-freedom nonlinear oscillator is carried out, with reference to the evaluation of the backbone curve, as well as principal, subharmonic, superharmonic, and parametric resonances. The analysis will then extend to two-degree-of-freedom oscillators, with the aim of considering internal resonance. Finally, mention will be made of the extension of the analysis to continuous systems.

Programme:

NLD1. Introduction to perturbation methods (3h)
NLD2. One-d.o.f. nonlinear oscillators: free oscillations and backbone curve (2h)
NLD3. One-d.o.f. nonlinear oscillators: forced oscillations, principal, subarmonic, superarmonic and parametric resonances (4h)
NLD4. Two-d.o.f. nonlinear oscillators: internal resonance (3h)
NLD5. Continuous systems: nonlinear oscillations of a beam (3h)

Suggested Readings:

[1] A.H. Nayfeh, D.T. Mook, *Nonlinear Oscillations*, John Wiley and Sons, New York, 1981

DOTTORATO DI RICERCA DI INTERESSE NAZIONALE

Defense against natural risks and ecological transtion of built environment
Difesa dai rischi naturali e transizione ecologica del costruito

Cycle XXXVIII - National School
Villa Citelli Via Tomaselli 31 Catania

June 2023

	Mo 5	Tu 6	We 7	Th 8	Fr 9		Mo 12	Tu 13	We 14	Th 15	Fr 16
8.30 11.30	***RISK1***	***CM1***	***RISK3***	***CM3***	***CM4***		***NLD1***	***NLD3***	***NLD4***	***CM8***	***Exams***
11.30 13.30	***RISK1***	***RISK2***	***CM2***	***RISK4***	***RISK4***		***NLD2***	***NLD3***	***NLD5***	***CM9***	
15.30 1830	***RISK2***	***RISK3***	***RISK4***	***RISK4***	***CM4***		***CM5***	***CM6***	***CM7***	***Seminars or discussions***	