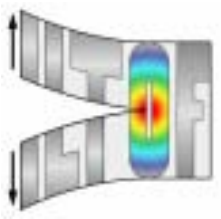


Course code	Course title
ILTOF/01	FRACTURE MECHANICS & COMPLEXITY SCIENCES

Course Summary

The course intends to provide the fundamental concepts of Nonlinear Fracture Mechanics as well as of Fractal Fracture Mechanics. Although this two advanced topics are both connected with Linear Elastic Fracture Mechanics, a specific and extended knowledge of the latter is not required to the attendants. On the other hand, the nonlinear and the fractal aspects are both very important for practical applications and may be treated in the framework of Complexity Sciences.

As a matter of fact, from simple nonlinear rules a catastrophic and/or chaotic mechanical behaviour may derive. Two significant examples are provided by the cohesive constitutive law and by the unilateral constraint condition between the crack faces. The former produces ductile versus brittle size-scale transitions, where the brittle crack propagation is described by cusp catastrophe or snap-back load versus deflection branches. The latter produces nonlinear or chaotic vibrations.

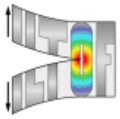
On the other hand, from apparently disordered or chaotic situations a relatively ordered and regular condition may emerge, if we consider the multi-scale and fractal character of damage, cracking and deformation. Renormalized or fractal quantities may be defined, which present anomalous and noninteger physical dimensions and represent the real scale-independent properties. The nominal quantities obey, on the other hand, scaling power-laws where the exponent reflects the fractal dimension of the set over which the same quantity is defined. In this context, damage, cracking and final rupture are seen as critical phenomena.

Training Objectives

The course is addressed to Master and Ph.D. students, post-doctoral fellows, young researchers, specialists in Fracture Mechanics working in the industry. A widening of knowledge is intended towards nonlinear fracture phenomena and statistical and disordered damage processes.

Prerequisites

A specific and extended preparation in Linear Elastic Fracture Mechanics is not explicitly required. On the other hand, basic concepts of solid and structural mechanics are necessary.



Author's Curriculum:

Prof. Dr. Alberto CARPINTERI

Chair of Structural Mechanics
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Academic Positions:

Professor of Structural Mechanics, Politecnico di Torino, Torino-Italy, 1986-.
Director Dept. Structural Engineering, Politecnico di Torino, Torino-Italy, 1989-1995.
Founding Member and Director – Graduate School in Structural Engineering, Politecnico di Torino, Torino-Italy, 1990-.
Visiting Professor, Lehigh University, Bethlehem-Pennsylvania, USA, 1982-1983.
Member of the New York Academy of Sciences (founded in 1817), New York, USA, 1997-.
Member of the American Association for the Advancement of Science (founded in 1848 at the Academy of Natural Sciences in Philadelphia, Pennsylvania, USA), 1999-.
Member of the American Academy of Mechanics, USA, 2003-.
Fellow of the Turin Academy of Sciences (founded by G.L. Lagrange in 1783), Torino-Italy, 2005-; Member, 1995-2005.
Member of the Istituto Lombardo – Accademia di Scienze e Lettere, Milano-Italy, 2006-.
Member of the Accademia Teatina per le Scienze, Chieti-Italy, 2006-.

Scientific Activity:

President of the European Structural Integrity Society (ESIS), 2002-2006.
President of the International Association of Fracture Mechanics for Concrete and Concrete Structures (IA-FraMCoS), 2004-2007.
President of the Italian Group of Fracture (IGF), 1998-2005.
Senior Vicepresident of the International Congress on Fracture (ICF), 2005-2009.
Vicepresident of the National Research Institute of Metrology (INRIM), 2006-2009.
Chairman of the Organizing Committee of the 11th International Conference on Fracture (ICF11), Torino, Italy, March 20-25, 2005.
Member of the Congress Committee of the International Union of Theoretical and Applied Mechanics (IUTAM), 2004-2008.
Co-Editor of the International Journal "Strength, Fracture & Complexity", 2003-; Member of the Editorial Board of six international journals.
Author of over 500 papers on fracture mechanics, material fatigue, thermoelasticity, seismic structures, reinforced concrete, structural monitoring, contact mechanics, fragmentation and comminution, drilling.
Author or Editor of 38 volumes.

Honours and Awards:

Recipient of Robert l'Hermite International Prize, RILEM, Paris, France, 1982.
Recipient of JSME Medal, Japan Society of Mechanical Engineers, Tokyo, Japan, 1993.
Doctor of Physics Honoris Causa, The Constantinian University, Cranston-Rhode Island, USA, 1994.
Recipient of International Cultural Diploma of Honor, American Biographical Institute, 1995.
Honorary Professor, Nanjing Architectural & Civil Engineering Institute, Nanjing, China, 1996.
Honorary Professor, Albert Schweitzer University, Geneva, Switzerland, 2000.
Recipient of WIT Eminent Scientist Award, Wessex Institute of Technology, Southampton, U.K., 2000.

Topic list

n.	Title	Summary	Lecturer	Duration
1	Crackling, brittle ruptures and Catastrophe Theory	On the basis of the Cohesive Crack Model, an original representation and interpretation of brittle ruptures is provided. Virtual branches of cusp catastrophe instability are captured by the model. When such branches are not adequately controlled, a snap-back instability occurs with energy release. In the cases of multiple energy releases, crackling noise is acustically emitted.	Alberto Carpinteri	2 h
2	Instability phenomena (snap-back and snap-through) in fibre-reinforced materials	On the basis of the Bridged Crack Model, snap-through and snap-back instabilities are analyzed in fibre-reinforced materials. The particular case of reinforced concrete is contemplated together with the related condition of minimum reinforcement.	Alberto Carpinteri	2 h
3	Period doubling and deterministic chaos in the vibration of cracked elements	Period dubling and transition to deterministic chaos is considered and analyzed in damaged materials and cracked structural elements. The effect of the unilateral constraint between the crack faces in closure is emphasized.	Alberto Carpinteri	1 h
4	Multi-scale and fractal character of the internal material structure	The reasons producing the fractal structure of natural objects and materials are presented and explained. In addition to the evident hierarchical features of the components, a more fundamental origin may be found in nonlinear dynamics and fractality of strange attractors.	Alberto Carpinteri	1 h
5	Renormalisation groups and scaling laws for stress, deformation and strain energy density	Assuming fractal patterns for damage, cracking and deformation, renormalized or fractal counterparts of stress, strain and fracture energy are defined. Such fractal quantities present anomalous, noninteger physical dimensions and represent the real scale-independent material properties. On the other hand, the usual nominal quantities become scale-dependent and vary with the size according to peculiar power-laws where the scaling exponent is connected to the fractal dimension of the same set over which the quantity is defined.	Alberto Carpinteri	3 h

6	Multifractal scaling laws for tensile strenght and fracture energy	The slope of the scaling laws as well as the fractality are maximum at the smallest scales, whereas they tend to vanish at the largest scales. This homogeneization effect is kept by a Multi-Fractal Scaling Law (MFSL), which is working very well for initially uncracked elements. Different well-known scaling laws for tensile strength are discussed and compared to MFSL.	Alberto Carpinteri	1 h
7	Fractional calculus and static-kinematic duality in the mechanics of fractal media	The concept of fractional derivative is applied to the equations of an elastic body deformable only over a fractal sub-set. The duality of the static and kinematic fractional operators is shown, as well as an extension of the Virtual Work Principle.	Alberto Carpinteri	1 h
8	Acoustic emission and critical phenomena in structural and seismic engineering	Acoustic emission and crackling noise are considered to experimentally detect damage and fracture processes occurring in structural elements or in the Earth crust. Localization, intensity and stability condition of the damage process may be obtained by the proposed method.	Alberto Carpinteri	1 h