Short Course On

Nonlocal Mechanics Approaches for Modelling Localized Deformations (NMAMLD)

19 - 21 Feb 2020
# Overview
This course provides an overview of modelling approaches used in the mechanics of elastic and inelastic materials and structures, with special attention to the objective description of highly localized deformation modes such as damage, fracture, and shear bands.

## Course Objectives
This course is intended to provide graduate students, engineers, and researchers working in aerospace, automotive, civil, mechanical engineering, and materials and manufacturing industries with the theory and applications of nonlocal and nonlinear mechanics approaches for modelling localized elastic and inelastic deformations.

## Benefits of attending the course
The persons attending the course will benefit in gaining knowledge and information in the following areas: (a) nonlocal mechanics theories, (b) nonlinear analysis, (c) elastic-plastic models, and (d) damage and fracture in solids.

## Course Material and Reference book
Course material/lecture notes and handouts will be provided to the participants of the course.

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# Course Contents

## Day 1 – 19th Feb 2020 Introduction to Nonlinear Finite Elements

### SESSION 1:
1. Introduction to nonlinear finite element analysis (FEM) through 1D and 2D model equations
2. Solution strategies in nonlinear algebraic equations (Picard’s and Newton’s methods)
3. Newton-Raphson method under load control, direct displacement control, and arc length control
4. Nonlinear analysis of structural problems (beams, plates, and shells)

## Day 2 – 20th Feb 2020, Introduction to Nonlocal Mechanics

### SESSION 1:
1. Introduction to generalized continuum models
2. Introduction to nonlocal theories
3. Strain localization and size effect
4. Strong discontinuity models
5. Regularized continuum models

### SESSION 2:
1. Nonlocal models for rods, beams, plates, and laminates
2. Introduction to PD theory

## Day 3 – 21st Feb 2020. Nonlocal damage mechanics and phase field approach

### SESSION 1:
1. Damage Mechanics (isotropic, anisotropic damage models, coupling of damage and plasticity)
2. Nonlocal damage models and nonlocal integral plasticity
3. Variational formulation of gradient damage models
4. Gradient enriched plasticity models
5. Phase field approaches to damage
About the speakers

Prof J N Reddy
Professor Reddy has made several significant contributions to research and education in applied mechanics, and computational mechanics in particular, through his works on primal-dual variational principles, refined shear deformation theories of composite plates and shells, linear and nonlinear finite element analysis of heat transfer, fluid mechanics, and solid and structural mechanics, nonlocal and nonclassical continuum mechanics, and authorship of many well-received text books. In particular, Reddy’s recent research deals with 6 and 12-parameter shell theories for accurate prediction of stresses, buckling loads, and frequencies of laminated composite structures and the development and application of non-local and non-classical continuum theories using the ideas of Eringen, Ericson, Mindlin, Koiter, and others. With his colleague Dr A R Srinivasa, Dr Reddy has developed a thermodynamically based strain gradient elasticity theory that contains Mindlin’s model as a special case. His works with K S Surana on non-classical continuum mechanics and with Debasish Roy of the Indian Institute of Science on discrete fracture and flow, micropolar cohesive damage, and continuum plasticity of metals are gaining attention.

Prof Arun Srinivasa
Dr. Srinivasa has earned an outstanding reputation as both a scholar and mechanical engineering educator. He is best known for his work on crystal plasticity and the dissipative response of solids and fluids as well as his innovative and deep scientific work on smart materials and structures. He has co-authored and edited 3 books, one of which is a graduate text on inelasticity (Inelasticity of Materials: An Engineering Approach and Practical Guide, World Scientific, 2009) and the other two on the modelling of smart materials and components (Smart Devices: Modelling of Material Systems, American Institute of Physics, 2008; Design of Shape Memory Alloy Actuators, Springer Briefs in Applied Sciences and Technology, 2015). Srinivasa and Reddy have developed a thermodynamically consistent formulation that accounts for the couple stress effects at continuum level (published in Journal of Mechanics and Physics of Solids) and a computational approach, termed GraFEA, for the prediction of fracture and its propagation (the idea appeared in Meccanica).

Dr Amirtham Rajagopal
Dr. Rajagopal’s research expertise is on computational in elasticity, finite element and mesh free methods. Earlier to joining IIT Hyderabad he worked as a post doctoral researcher at the Chair of applied mechanics, University of Erlangen, Nuremberg, Germany, under the guidance of Prof. Paul Steinmann. During this time he has worked in the area of polygonal finite element and mesh free methods applied to nonlinear gradient elasticity and phase field simulations. Earlier he has obtained his PhD from IIT Madras, on developing Finite Element Mesh adaption techniques based on mechanics of material / configurational forces for plane problems, bimaterial interfaces and composite plates under guidance of Prof C S Krishnamoorthy and Prof M Sivakumar. He has authored several papers in these areas in leading journals.

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About IIT Hyderabad

IIT Hyderabad is in its 10th year. We have come a long way in the last 9 years. Academically, we are at the forefront of developing new curricula and new programs. We are also at the forefront of research and development. Our faculty student ratio is the best among all IITs — 1:13. We have a very strong PG program. The rough ratio among Ph.D. students, Masters students and undergraduate students is 30:25:45. IITH has graduated 143 Ph.D. students by Feb 28, 2018. In March 2018 IITH has a total of 2374 students with almost 20% women students, and 185 faculty members. IITH sanctioned research funding will be to the tune of Rs.300 crs. from sponsored projects and consultancy projects. Nearly 80% of IITH faculty have sponsored projects. IITH Scopus indexed publications will stand at 3000 with one transfer of technology and nearly 85 filed patents. IITH has strong industry collaboration we collaborate with nearly 50 industries. IITH achieved NIRF ranking of 10 and QS Asia BRICS ranking of 100. Our Japan collaboration is in full swing with Japanese faculty visiting us and IITH faculty visiting leading Japanese university on a regular basis. There is a strong student exchange program with Japan. IITH has MOUs with at least 50 universities globally, most of them in Japan, USA, Australia, Canada, Europe and Taiwan. IITH has three technology incubators – iTIC, Center for Healthcare Entrepreneurship and Fabless Chip Design Incubator with 10 incubated companies of these 4 have received substantial funding. Moreover, there are 6 research centres most notable being Nano-technology, Teaching and Learning Center, Design Innovations Center. On the academic front IITH is innovating and scaling while maintaining quality. We have B.Tech. programs in 9 engineering departments, MSc in Physics, Chemistry and Mathematics, M.Phil. in Liberal Arts, M.Des. in Design, and Ph.D. in all 13 departments. There is strong emphasis on interdisciplinary academics. IITH has implemented a very novel academic program, referred to as, Fractal Academics – the key idea is to atomize courses, provide breadth and depth, emphasize courses in liberal arts as well as creative arts, emphasize project work, and create an interactive learning ambience. In this approach the students will be well equipped to handle challenges of any job or challenges of post graduate education. IITH offers a Minor in Entrepreneurship to all students, a double major — hardworking and enthusiastic student can get two B.Tech degrees. Students at IITH can enrich their knowledge by opting for a minor and/or an honors program. IITH is the only institution to offer DigiFab (3D-printing) to all first year students. IITH is the first institute to start an executive M.Tech. program in Data Science for working professionals, and an all course M.Tech. program which can be completed in one year. IITH is creating a unique holistic educational ecosystem that offers interactive learning, a highly, flexible academic structure, cutting edge research, strong industry collaboration, and entrepreneurship. It is providing an environment wherein students and faculty are not afraid to experiment and celebrate their ideas.