SHORT TERM COURSE

in Continuation of the Fulbright Specialist Program (FSP)

to be Conducted during 24^{th} May – 3^{rd} June 2025

on "Nonlinear Dynamics and Bifurcations in Classical Solids"

on

Computational Mathematics for Boundary Value Problems (BVPs) and Initial Value Problems (IVPs)

by

PROF. KARAN S. SURANA, UNIVERSITY OF KANSAS, USA

(4^{th} - 8^{th} June 2025)

Organized By:

Department of Mechanical Engineering

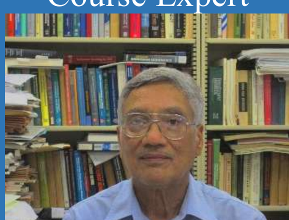
MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

J L N Marg, Malviya Nagar, Jaipur, Rajasthan -302017

Website: www.mnit.ac.in

About MNIT Jaipur	Malaviya National Institute of Technology (MNIT) Jaipur, established in 1963 as Malaviya Regional Engineering College (MREC), was later recognized as a National Institute of Technology (NIT) in 2002 and designated as an Institute of National Importance by the Government of India. Spread across 317 acres, the institute boasts modern infrastructure, including smart classrooms, advanced laboratories, research centers, a central library, computing resources, residential quarters, and sports complexes. Offering undergraduate, postgraduate, and doctoral programs across disciplines such as Engineering, Science, Management, and Humanities, MNIT Jaipur is a hub for cutting-edge research in renewable energy, artificial intelligence, nanotechnology, and structural engineering, collaborating with institutions like IITs, ISRO, DRDO, and international universities. The institute is home to Centers of Excellence in Renewable Energy, Materials Science, and Cyber-Physical Systems, actively promotes startups and innovation through its Technology Business Incubator (TBI), and frequently hosts national and international conferences, workshops, and training programs. With its strong emphasis on academic excellence, research, and industry collaborations, MNIT Jaipur continues to be a leading institution shaping future innovators and technologists.
Overview of this course	Computational mathematics is a branch of applied mathematics devoted to the study of methodologies, techniques and algorithms for obtaining numerical solutions of the boundary value problems (BVPs) and initial value problems (IVPs) arising in science, engineering, physics and applied mathematics. The course material is designed to address totality of all BVPs and IVPs with the same rigor regardless of their field of origin and application or level of complexities of their mathematical descriptions. In order to accomplish this, all differential operators appearing in totality of all BVPs and IVPs are mathematically classified in three categories: self adjoint, nonself adjoint and nonlinear. Since the solutions of differential systems (BVPs and IVPs) must be obtained by integration, the only mathematically sound and correct approach to seek the solution of BVPs and IVPs is to use calculus of variations, a field of applied mathematics that seeks extremum of functionals. In this approach, definite integrals are constructed over the domain of the definition of the BVP or IVP using fundamental lemma or using the residual functionals. When the functionals are continuous in their arguments, then its first variation is unique and when set to zero gives the necessary condition from which we can determine a function that yields extremum of the functional. A unique second variation of the functional gives sufficient condition that ensures that the solution obtained from the first variation set to zero is unique. Based on calculus of variations, this solution also satisfies Euler’s equation that can be derived from the first variation of the functional set to zero. Since the functionals using fundamental lemma or residual functions are constructed using BVPs and IVPs, the Euler’s equation is always BVP or IVP. Thus, we have a technique of obtaining solutions of BVPs and IVPs through extremums of functionals. An integral form that yields unique extremum principle is called variationally consistent (VC) integral form and others are variationally inconsistent (VIC) integral forms. VC integral form ensures unconditionally stable computational processes. In this course, we study VC integral forms for BVPs and IVPs as means of obtaining their numerical solutions. Only finite element method is mathematically, rigorous and extremely versatile methodology that can be used in conjunction with VC integral forms. Detailed study of VC integral form for BVPs and IVPs and associated finite element infrastructure is the main aim of the course. Simplicity, generality and the mathematical rigor of the method permits its use in solving BVPs and IVPs in any discipline of physical and mathematical sciences and other areas as well. Development of complete computational infrastructure, convergences, convergence rates, a priori error estimation, a posteriori error computation, model problem studies in tutorial sessions are all included as part of the instructions in this course.

Objectives of the course	The objectives of this course are as follows: • To study computational mathematics and methodologies that ensure unconditionally stable solutions for all boundary value problems (BVPs) and initial value problems (IVPs), irrespective of their origin, application field, or model complexity—including those in solid and fluid mechanics, physical sciences, and applied mathematics. • To understand the computational infrastructure of BVPs and IVPs with a focus on finite element methods, including space-time coupled and decoupled approaches for IVPs. • To develop working knowledge of advanced VC integral forms and high-degree/high-order local approximations (hpk). • To study discretization, local approximations, element functionals and algebraic relations, assembly procedures, application of boundary/initial conditions, solution techniques, and post-processing. • To explore structural dynamics, modal synthesis, and the stability of time integration methods. • To examine convergence behavior, convergence rates, a priori and a posteriori error estimation, and numerical methods for solving algebraic systems and time-dependent ODEs.
Who should attend the course	The course is designed for graduate students (B.Tech./M.Sc./M.Tech./Ph.D.), faculty members from academic and technical institutions, and professionals—engineers, researchers, and scientists in physical sciences and applied mathematics—seeking in-depth knowledge of: 📌 Computational mathematics frameworks for unconditionally stable numerical solutions of BVPs and IVPs, regardless of their origin, application domain, or model complexity. 📌 Variationally consistent integral forms for BVPs and IVPs, supporting unconditional stability, high-degree p-version hierarchical approximations, and higher-order scalar product spaces ensuring global differentiability. 📌 Users of FDM, FVM, and FEM-based computational tools will gain valuable insights into the underlying mathematical formulations enabling reliable simulations—applicable to both solid mechanics and CFD, including compressible and incompressible deformation physics. ***Eligibility:*** An undergraduate degree in engineering, mathematics, or physical sciences is sufficient to attend.
Course Fees	The participation fees (**excluding food and accommodation charges**) for taking the course is as follows: ● Participants from abroad: US$100 ● Industry/Research Organizations: Rs. 3000 /- ● Faculty from Indian academic Institutions: Rs. 1000 /- ● Research Scholars and students: Rs. 500/-
Registration & Mode of fee payment	Participants are required to transfer the Course Fee through NEFT/RTGS by ***20th May, 2025*** in the following account. **Name**: Registrar (Sponsored research) MNIT Jaipur; **Account no.**: 676801700388; **Bank name**: ICIC bank Ltd. **IFCS code**: ICIC0006768, Branch: MREC (MNIT) Jaipur, and fill the registration form by 20th May 2025 using the following QR code or link: https://forms.gle/JQbS9vHA3zCMDRmB9

Accommodation	Limited accommodation in the Institute Hostels/Guest Houses may be arranged on payment basis on prior request, subject to the availability OR otherwise participants will have to make their own stay and food arrangements.
About Jaipur	**Jaipur – The Pink City-** the Capital of Rajasthan is famed for its pink sandstone architecture and Rajput heritage. Its forts and palaces remain top tourist draws. ***Famous For:*** Embroidered leather shoes, Blue pottery, Tie-and-dye scarves, Traditional handicrafts, A gateway to Western Rajasthan and the Thar Desert, the city blends rich history with vibrant culture. ***May Month Weather:*** Hot days (38–45°C / 100–113°F), warm nights (25–30°C / 77–86°F). Wear light cotton, stay hydrated, and use sun protection. ***Must-Visit Sites:*** Hawa Mahal, Jantar Mantar, City Palace, Albert Hall Museum, Amber Fort, Nahargarh Fort, Jaigarh Fort, Jal Mahal, Kanak Vrindavan Garden, Govind Dev Ji Temple.
How to Reach MNIT Jaipur	Jaipur is well connected by Air, Road and Rail with all the major cities and railway stations in India. It is about 280 Kms from New Delhi. It has direct flights from New Delhi (45 min), Mumbai (1.5 hrs) and Kolkata (2.2 hrs). The Institute is prominently located on JLN Marg and is 15 minutes from the Airport. It is 10 Kms from the main Railway Station and Bus Stand. You can easily hire taxis/autos (OLA, UBER, and other local service providers) in Jaipur around the clock.
Course Expert  Prof. Karan S. Surana	Karan S. Surana, born in India, went to undergraduate school at BITS, Pilani, India, and received a B.E. in Mechanical Engineering in 1965. He then attended the University of Wisconsin, Madison, where he obtained M.S. and Ph.D. degrees in Mechanical Engineering in 1967 and 1970, respectively. He worked in industry, in R&D in various areas of computational mechanics and software development, for fifteen years. In 1984, he joined the Department of Mechanical Engineering faculty at the University of Kansas, where he is currently the Deane E. Ackers University Distinguished Professor of Mechanical Engineering. His areas of interest and expertise are computational mathematics, computational mechanics, and continuum mechanics. He is the author of over 350 research reports, conference papers, and journal articles. He has served as advisor and chairman of 50 M.S. students and 25 Ph.D. students in various areas of Computational Mathematics and Continuum Mechanics. He has delivered many plenary and keynote lectures in various national and international conferences and congresses on computational mathematics, computational mechanics, and continuum mechanics. He has served on international advisory committees of many conferences and has co-organized mini-symposia on k-version of the finite element method, computational methods, and constitutive theories at U.S. National Congresses of Computational Mechanics organized by the U.S. Association of Computational Mechanics (USACM). He has organized mini-symposium on classical and non-classical continuum mechanics at SES (Society of Engineering Science). He is a member of the International Association of Computational Mechanics (IACM) USACM, SES, and a fellow and life member of ASME. Dr. Surana's most notable contributions include: large deformation FE formulations of shells, the k-version of the FEM, operator classification and variationally consistent integral forms in methods of approximations for BVPs and IVPs, and ordered rate constitutive theories for solid and fluent continua. His most recent and present research work is in non-classical continuum theories for solid and fluent continua and associated constitutive theories. He is the author of recently published textbooks: Advanced Mechanics of Continua, CRC/Taylor & France, The Finite Element Method for Boundary Value Problems: Mathematics and Computations, CRC/Taylor & Francis, The Finite Element Method for Initial Value Problems: Mathematics and Computations, CRC/Taylor & Francis, and Numerical Methods and Methods of Approximation in Science and Engineering, CRC/Taylor & Francis. You may reach him at: **kssurana@ku.edu.**

Course Coordinators:	Dr. Dinesh Kumar Associate Professor, Department of Mechanical Engineering Malaviya National Institute of Technology Jaipur, J. L. N. Marg, Jaipur – 302017, Rajasthan, India Mob. No.: 9549654562; Email: dkumar.mech@mnit.ac.in Dr. Makkhan Lal Meena Associate Professor, Department of Mechanical Engineering Malaviya National Institute of Technology Jaipur, J. L. N. Marg, Jaipur – 302017, Rajasthan, India Mob. No.: 9549654505; Email: mlmeena.mech@mnit.ac.in	 
	Dr. Naresh Kumar Raghuwanshi Assistant Professor, Department of Mechanical Engineering Malaviya National Institute of Technology Jaipur, J. L. N. Marg, Jaipur – 302017, Rajasthan, India Mob. No.: 99937 23778; Email: naresh.mech@mnit.ac.in	
	Dr. Gulab Pamnani Assistant Professor, Department of Mechanical Engineering Malaviya National Institute of Technology Jaipur, J. L. N. Marg, Jaipur – 302017, Rajasthan, India Mob. No.: 7489 455 666; Email: gulab.mech@mnit.ac.in	
	Dr. Dinesh Kumar Rathore Assistant Professor, Department of Mechanical Engineering Malaviya National Institute of Technology Jaipur, J. L. N. Marg, Jaipur – 302017, Rajasthan, India Mob. No.: 82608 43176; Email: dkrathore.mech@mnit.ac.in	
	Dr. Preeti Gulia Assistant Professor, Department of Mechanical Engineering Malaviya National Institute of Technology Jaipur, J. L. N. Marg, Jaipur – 302017, Rajasthan, India Mob. No.: 95401 76819; Email: preetigulia.mech@mnit.ac.in	
Contact person	***Dr. Dinesh Kumar:-*** Email: dkumar.mech@mnit.ac.in**;** Mobile: 09549654562.	