PSEUDO-SPECTRAL METHODS AND THEIR APPLICATIONS IN SOLVING SYSTEM OF DIFFERENTIAL EQUATIONS

Overview

Mathematical modelling plays a crucial role in understanding the many processes in the application of science and technology. Many mathematical models are formulated in the form of systems of Ordinary Differential Equations (ODEs) or Partial Differential Equations (PDEs) which are either linear or nonlinear. There are several accurate analytical and numerical methods available for solving the linear differential equations, but solving nonlinear differential equations is a highly complex task in many engineering and research fields. Keeping this in mind, the course on pseudo-spectral methods is developed for the engineers, researchers and scientists.

In recent years there has been a burgeoning interest in numerical methods such as Spectral methods in solving differential equations related to several complex problems in applied mathematics, engineering and other areas of scientific computations. Techniques based on spectral methods have been developed for solving a plethora of applications such as astrophysics, wave propagation, aeronautics and engineering, financial mathematics and fluid mechanics. Pseudo-spectral methods are closely related to spectral methods, but complement the basis by an additional pseudo-spectral basis, which allows representing functions on a quadrature grid. They are mainly used to solve the partial differential equations. Compared to traditional methods for solving ODEs and PDEs, such as finite differences and finite element methods, the pseudo-spectral methods have been observed to have superior accuracy, particularly for smooth functions. Using Fourier and Chebyshev expansions, and polynomial interpolation functions, spectral methods have been found to be relatively easy to learn and even to apply in most of the complex problems. This proposed course has been designed specifically to give the student a thorough foundation in pseudo-spectral methods.

The course is planned to cover basics of spectral methods and their applications in solving ODEs/PDEs using relaxation methods and Taylor series based linearization methods. In particular, methods such as the Spectral Relaxation Method, Spectral Local linearization method and Pseudo-Spectral Methods for parabolic PDEs will be discussed. The course offers a hands-on training to some spectral and pseudo-spectral collocation methods with emphasis on implementation in MATHEMATICA and MATLAB. Particular focus will be directed in designing the accurate and efficient pseudo-spectral collocation-based algorithms for solving ODEs and PDEs of practical interest like unsteady boundary layer problems. The course emphasizes the practical derivation and implementation of spectral and pseudo-spectral methods over abstract mathematics. As part of the tutorial sessions, hands-on training will be provided where participants will be challenged to implement the algorithms in computer code to solve problems of physical relevance using various techniques and methods discussed in the course.

Dates	**January 15 -25, 2018**
Venue	**CAD LAB, 2nd floor, Department of Mechanical Engineering, BMSCE**
Modules	**1. Monomial and Lagrange interpolation on unequal grids.** **2. Collocation Methods with monomial basis, Lagrange and Chebyshev polynomials.** **3. Matrix based approach to interpolation and collocation.** **4. Theory of pseudo-spectral collocation methods for two point-BVPs.** **5. Derivative boundary conditions in pseudo-spectral methods and their application in solving higher order differential equations.** **6. Simplifying non-linear two-point BVPs, solving linearized two point BVPs using pseudo-spectral methods.** **7. Linear and Non-Linear systems of higher order differential equations and Pseudo-spectral method to solve linear/nonlinear systems of equations.** **8. Spectral Relaxation Method (SRM) and Local linearization Method (LLM).** **9. Pseudo-spectral methods for PDEs, Pseudo-spectral methods for parabolic equations.** **10. Pseudo-spectral methods for PDEs involving flow problems in fluid mechanics.** **11. Pseudo-spectral methods for unsteady boundary layer flows**
You Should Attend If…	▪ **You have Knowledge of differential equations and Interpolation.** ▪ **you are an engineer or research scientist interested in mathematical modelling and designing of new numerical methods to solve ODEs and PDEs** ▪ **you are a student or faculty from academic institution interested in learning how to do research on fluid flows, heat transfer and boundary layer flows.**
Fees	The participation fees for taking the course is as follows: **Participants from abroad : US $150** **Industry/ Research Organizations: Rs. 10000** **Academic Institutions: Rs. 5000** **Research Scholars : Rs. 2000** The above fee include all instructional materials, computer use for tutorials and assignments, 24 hrs free internet facility, snacks and coffee during breaks. The participants will be provided with accommodation on payment basis.
Participants	**Number of participants for the course will be limited to fifty.**

The Faculty

Professor Sandile Motsa has over 15 years of research and teaching experience. He obtained his Ph.D., degrees in applied mathematics from the University of Zimbabwe in 2001. He worked at the University of Swaziland for about 10 years later in 2011 joined the University of KwaZulu-Natal (UKZN) as Associate Professor of Applied Mathematics. He served 5 years at UKZN and returned back to the University of Swaziland in December 2016. His research projects are mainly focused on developing new methods for solving mathematical models that emanate from all areas of science and engineering. He is passionate about using technology to solve mathematical problems modelled as differential equations. His research articles have appeared in over 150 leading academic journals in applied mathematics, physics and engineering. His other research outputs includes over 10 chapters in various books and over 10 technical reports and lecture notes that he has developed for international workshops he has facilitated in. Prof. Motsa is one of the editorial board of two international journals, Journal of Applied Fluid Mechanics and Journal of Interpolation and Approximation in Scientific Computing and was lead guest editor of a special issue of Mathematical Problems in Engineering in 2014. He regularly reviews journal articles for over 40 leading international journals. He also serves as the Vice President of the Southern Africa Mathematical Sciences Association (SAMSA).

Dr. Chandra Shekara G., has over 9 years of research and teaching experience. Obtained Ph.D degree from Bangalore University in Applied Mathematics in the year 2013. He is working as assistant professor in the Department of Mathematics, B.M.S. College of Engineering from 2011. His research projects are mainly on interfacial instabilities at the interface between different fluids, heat and mass transfer, convective instabilities and generalized eigenvalue problem. Published 10 articles in leading international journals, 5 conference papers and presented more than 10 papers in various international conferences. His research interest also extended to Numerical methods like Finite Difference Methods and Spectral Methods and their implementation in MATLAB.

Dr. GAYATHRI M. S., has over 15 years of teaching and 10 years of research experience. Obtained Ph.D degree in Applied Mathematics from Bangalore University in the year 2008. She was the recipient of 2 Gold medals in her Master Degree. She is working as assistant professor in the Department of Mathematics, B.M.S. College of Engineering from 2007. Her research interests are mainly focused on Convective instabilities of time dependent fluid flows in the presence of an external fields. Her research field also extended to the implementation of numerical methods like Galerkin Residual method and Spectral Methods for differential equations. She published 6 articles in leading international journals and proceedings of international conferences. She presented a paper in the International conference on Plasma Fluids, held at Verenna Italy in 2005.

Course Co-ordinators

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